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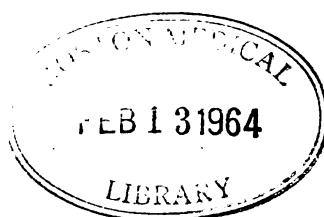
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BOVINE TUBERCULOSIS
AND ITS CONTROL

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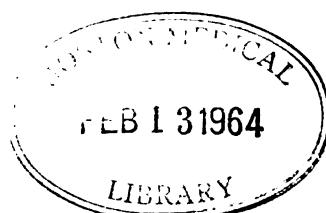






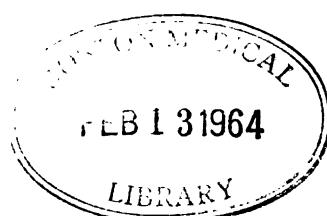
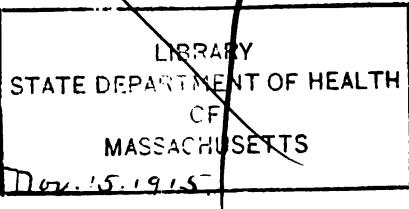
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DR ROBERT KOCH WHO DISCOVERED THE CAUSE OF TUBERCULOSIS

BOVINE TUBERCULOSIS AND ITS CONTROL

BY

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and Director of the College**

THIRTY FULL PAGE ILLUSTRATIONS

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**TO THOSE WHO ARE ACTIVELY
INTERESTED IN THE ERADICATION
OF BOVINE TUBERCULOSIS THIS
VOLUME IS DEDICATED.**

PREFACE

THE early belief that the bacteria of human and of bovine tuberculosis were identical and that large numbers of people became infected from diseased cattle caused bovine tuberculosis to stand out somewhat conspicuously among the affections of animals.

The sanitary significance of this affection in addition to its great economic importance have caused it to be very carefully studied in each and all of its phases. Although there is still much to be ascertained concerning it, knowledge of this disease has become quite definite in many respects. However, it is a complicated subject with many difficult questions still to be answered. These relate to the various diagnostic tests and the differentiation of its cause from closely allied species of bacteria.

The preparation of this volume was undertaken largely at the instance of practitioners of veterinary medicine and health officers who during recent years have sought for a summary of the knowledge of bovine tuberculosis and its control. It seemed that for those who are intelligently working to eradicate this scourge benefit would be derived from bringing together the results of the more important investigations on the nature, diagnosis and various methods for the control of this disease.

Individuals, commissions, government laboratory workers and state experiment stations have made many contributions to the knowledge of this subject. While it is impossible to summarize this literature, the publications listed and the citations given will, it is believed, make it possible for those interested in the subject to ascertain fully the details of the work that has been done on this disease.

I am indebted to Dr. S. H. Burnett of this laboratory and Dr. A. R. Keith for the photographs from which the illustrations were made. The original specimens are in the collection of the Department of Comparative Pathology and Bacteriology of the New York State Veterinary College.

V. A. M.

ITHACA, N. Y., JANUARY, 1913.

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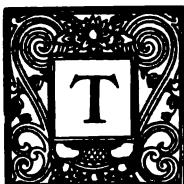
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CHAPTER I

HISTORY OF TUBERCULOSIS IN CATTLE



TUBERCULOSIS is one of the oldest diseases of cattle of which we have identifying records. The Mosaic laws (Leviticus xxii, 22) contain rules that the flesh of animals which suffer from "wen or scurvy" should not be used as food. The Talmud, especially the Mishnah, codified at the close of the second century, and the Gemara (fifth century) contain numerous enactments against the eating of such flesh. It is stated on good authority that "kandi" and "timari" refer to tuberculosis. It is evident that in the eleventh and twelfth centuries, tuberculosis was fairly well known to the Arabian Rabbi, Isaak ben Jacob Alfasi, an authority on the Talmud, and the French physician Rashi (1040-1105).

In the ninth century, the Franks enacted ecclesiastical laws against the eating of the flesh of cattle and swine which were affected with tuberculosis of the serous membranes. In 1370 it was forbidden in Munich to offer for sale the flesh of tuberculous animals. Similar laws were passed in 1343 in Würzburg; in 1394 in Passau; in 1401 in Landshut; in 1558 in Würtemburg; and later similar regulations were enforced in other provinces.

In 1702 Florinus gave a description of the symptoms of the disease during life. At that time the name "French disease" was applied to it in Germany. This grew out of the belief which prevailed in certain quarters that tuberculosis was connected with or related to human syphilis. The term *Franzosenkrankheit* is said to have been first used by Helmont. In consequence of this theory of its origin, all tuberculous cattle had to be destroyed. Severe penalties were imposed for the violation of this sanitary law.

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In 1783, the Berlin Board of Health published regulations for meat inspection in which the characteristics of the "French disease" were described; rejected the theory that tuberculosis was related to syphilis; and made the declaration that the flesh of tuberculous cattle was fit for human food. In the same year, Kersting of Hanover expressed a similar view in a report to the Government of Mecklenburg-Strelitz. Franck of Baden expressed the opinion that the consumption of the flesh of cattle which were only slightly affected with tuberculosis might be permitted. Graumann declared in 1784, in a government order of Mecklenburg-Schwerin, that such meat might be eaten. Following this declaration and perhaps in consequence of it, all the orders throughout Prussia which had been issued against the consumption of the flesh of tuberculous cattle were cancelled in 1785, and throughout Austria in 1788.

In 1816, Tscheulin laid down certain rules with regard to the inspection of meat from tuberculous cattle in which three stages or degrees in the extent of the disease of bovine tuberculosis were recognized, namely: (1) that in which only the tubercles were to be removed; (2) that in which the diseased parts were to be destroyed and the balance of the meat to be sold at a cheap price; and (3) carcasses which were declared to be entirely unfit for food owing to the extent of the disease. A similar procedure regarding meat inspection was carried out in Southern Germany, Switzerland, Austria, France, Belgium, Spain, Italy and other countries.

Consumption and bovine tuberculosis were for many years considered as two different diseases. Thus Virchow, Schüppel, and others declared that the tubercles in cattle were lymphosarcomata. Leisering regarded them as sarcomata. On the other hand, Spinola and Haubner maintained that bovine tuberculosis and human tuberculosis were identical.

Klencke* published a work in 1846 in which he accuses

*Klencke. Ueber Aussteckung u. Verbreitung der Scrophelkrankheit bei Menschen durch den Genuss der Kuhmilch. Leipzig, 1846.

cow's milk of being the cause of a certain sickness in children. He maintained that there is a positive connection between the milk of scrofulous and tuberculous cows and the frequent development of scrofula (tuberculosis of the glands of the neck) in bottle-fed children. His observations seem to be the first recorded concerning the direct communicability of tuberculosis. In 1865, tuberculosis was demonstrated to be infectious. In that year, Villemin showed that it could be produced in healthy animals by inoculating them with pieces of tuberculous tissue. His results were confirmed by a number of other investigators. Thus Chauveau, in 1868, produced tuberculosis experimentally by feeding tuberculous material to cows. These experiments were confirmed by Klebs, Cohnheim and Gerlach. The last mentioned was the first to show that tuberculosis could be produced by feeding animals the flesh and milk of tuberculous cattle. As a result of these experiments, attempts were at once made to prevent the sale of the flesh of tuberculous animals. Since the previous regulations respecting the sale of tuberculous meat had already been abrogated, or were in force in but a few places, these attempts were met by the vigorous opposition of those financially interested.

There was, perhaps, a tendency at that time for hygienists to take an extreme position as to the danger of using the products of tuberculous animals. For instance, Gerlach said: "Pearl disease is not only incurable but it renders the animal completely worthless; meat and milk from such animals are never to be used as human food in a raw or imperfectly cooked condition."

It must be remembered in this connection that the early stages of tuberculosis as now recognized were then almost unknown, for a cow that was then considered to be tuberculous was in a rather advanced stage of disease. As earlier stages of the disease were recognized, the German veterinary council took a more conservative position and in 1875 rendered an opinion to the effect that experience and observation did

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not justify the extreme measures that were advocated by many, and the Imperial authorities were asked to furnish means for the study of the question as to whether, and to what extent, the use of the flesh and milk of tuberculous cattle could be injurious to people. The results of this further study have brought about the development of rigid systems of meat inspection. The United States stands foremost in the efficiency of this service.

In 1882, Robert Koch discovered the bacterium (bacillus) of tuberculosis and thus completed the already abundant evidence that tuberculosis was a specific, infectious disease. The finding of its specific cause led to many careful and extended investigations into its nature, the means by which it is spread, and the measures that must be adopted if its spread is to be checked.

The discovery of tuberculin by Robert Koch in 1890 marked the beginning of widespread efforts to eradicate bovine tuberculosis. The later discovery by Theobald Smith that bovine and human tubercle bacteria were not identical in their morphology, cultural characters and virulence precipitated one of the most intense scientific investigations that modern medicine has witnessed. It has been participated in by a very large number of sanitarians, bacteriologists and pathologists in many countries. The results of these numerous inquiries have given us very definite knowledge of the nature of the disease which, if properly applied, will, it is believed, enable cattle owners to eliminate tuberculosis from their herds, if it is there, and to keep it out, if it is not present.

CHAPTER II

DISTRIBUTION, ECONOMIC AND SANITARY IMPORTANCE OF BOVINE TUBERCULOSIS

At the present time, tuberculosis is a wide-spread disease among cattle. It is reported to be more or less prevalent in nearly every locality where dairying is an active industry. It is also found in range cattle where it has been introduced with breeding stock. Ward states that 10 per cent of the cattle killed in the South San Francisco stock yards that came from the open ranges were tuberculous. In those parts of the country where the dairy industry is restricted to small herds and where there has been very little exchange of cattle it is rare. On the other hand, where milk production is the chief occupation of the people and where the supply of milk is continuous throughout the year, tuberculosis among cattle is very common. Thus we find the spread of this disease greatly aided by the habits of dairymen that were adopted to meet the demands of the cities for fresh milk. Dr. Melvin, Chief of the Bureau of Animal Industry, states that it is estimated that about 10 per cent of the dairy cattle of the country are infected.

In tracing the spread of tuberculosis it is found that it was introduced into certain localities of Western Europe and into America, from which centers it spread somewhat slowly at first but gradually increased with the development of the cattle traffic. From the infected localities it extended to uninfected ones through the introduction of one or more diseased animals. The cattle of Denmark, according to Prof. Bang, became infected from those imported from Scotland. The United States and Canada introduced tuberculosis in a similar manner although it is not known from what country or at just what time it occurred.

The early history of tuberculosis in cattle in the United

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States and Canada is very obscure. A careful search in the papers, magazines and published reports of Agricultural Societies and organizations as well as the veterinary literature fails to reveal evidence of the time of its first introduction into this country. In the American Farmer for 1822 (p. 152), Dr. Eli S. Davis of Abbeville, S. C., concludes that the theory of the contagiousness of tuberculosis is false. The Farmer's Companion and Horticultural Gazette for 1852 mentions consumption as one of the most dangerous diseases of cattle and one which "will become mortal if not immediately attended to." The report of the Massachusetts Society of Agriculture for 1880 points out that certain cases of suspected contagious pleuro-pneumonia of cattle were cases of tuberculosis. There are very few references to tuberculosis in cattle in this country prior to 1865; indeed the agricultural and veterinary literature* contains little about this disease until after Koch had discovered its cause in 1882. Attention was centered on tuberculosis in cattle in 1890 when it was found that tuberculin caused a reaction in many animals apparently healthy but on post mortem found to contain somewhere in their bodies small or larger active tubercles.

In 1907, in order to determine the extent to which the disease had spread in certain dairy districts of New York, I collected the results of a number of tests that were made during that and previous years, but largely in 1907, by a considerable number of veterinarians to whom tuberculin had been furnished. The results showed that of 421 herds tested, 302 contained cattle that reacted. These herds contained a total of 9,633 animals, of which 3,432 reacted. The herds were distributed in 39 counties. The greater number of the tests were made for one or the other of the three following reasons, namely: (1) when the herd was suspected of being diseased; (2) when the purchasers of animals required the test before accepting the

*The Veterinarian (London) in 1830 (Vol. VI) describes the symptoms and treatment of consumption in cows.

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cattle; and (3) when the purchasers of the milk or its products required that the cows should be tuberculosis free.

The official tests by the State Department of Agriculture for the years 1904-6 inclusive, kindly furnished me by Dr. Kelly then acting Chief Veterinarian, include 262 herds with a total of 3,088 animals, of which 673 reacted. They were distributed in fifty counties. These herds all came under the operation of the law. Infected animals were found in 121 herds.

The reliable available data for New York State at that time were restricted to 683 herds, aggregating 12,721 animals, distributed in fifty counties. Of the 683 herds, 423 contained reacting individuals. A small percentage of the reactors gave physical evidence of being diseased. Although these figures show a somewhat extensive infection of the herds examined it must be remembered that they represented only about one-half of one per cent of the cattle of the State, and those from the sections presumably most highly infected.

The reports of tuberculin tests in other states show that in dairy districts where the herds have been built up by the indiscriminate purchase of cows the disease is quite prevalent. The number of animals that are infected can not be determined as but a small percentage of them are tested. It seems to be very clearly established that there are localities where it is much more prevalent than elsewhere. It is also clearly shown that there are many places where farmers have not bought cattle from without, at least to any appreciable degree, and that tuberculosis is rare in these localities. The fact, however, that it has been reported from nearly if not all dairy districts in the United States warrants the general assertion that it is widespread.

In considering the economic importance of tuberculosis among cattle the essential fact relative to its distribution must be kept in mind. When it is once introduced, it is liable to spread from infected to well animals with more or less rapidity.

The time necessary for a tuberculous cow to infect a large percentage of the cattle in the herd depends upon the rapidity with which the lesions in the infected animal develop to the stage where the tubercle bacteria are thrown off. There is a great difference in the length of time required for this development. In some cases the tuberculous areas become surrounded with a wall of fibrous tissue which checks the growth and the animal may never show evidence of its presence. In other animals the infection may result in the rapid spread of the disease within the body and in the course of a few weeks or months tuberculous areas may discharge into some channel of excretion and the organisms be eliminated with either the saliva, feces, uterine discharges or the milk. It is impossible, therefore, to predict when a cow that reacts to tuberculin but appears to be perfectly well physically will spread the virus. This difference in the rapidity with which the disease develops depends upon the virulence of the infecting organism and the resistance of the animal. Pathogenic bacteria such as those of tuberculosis are not always possessed of the same degree of disease producing power. The resisting power of different individuals and even of the same individual under different conditions varies. It is impossible in the natural course of infection to determine the degree or extent of either of these factors. If this phase of the disease is understood it will explain why some animals that react continue to remain apparently well, while others develop physical signs of the disease and infect many individuals in the herd within a period of a few months. While these facts pertain to the nature of the disease, they are important in this connection to explain why some herds become infected rapidly and others more slowly or not at all after the introduction of a reacting animal or animals.

Economic Importance. It is difficult to estimate the loss from bovine tuberculosis. There are many ways in which it operates financially against owners of livestock. Briefly stated, they are as follows:

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1. By destroying cattle outright, as when tuberculosis is allowed to reach its full development and kill its victim.
2. By reducing the market value of the animal, as in those cases in which the beast is sold before the disease has reached such a stage as to render it entirely unmarketable.
3. By reducing the breeding value of a herd and its general productivity.
4. By causing a waste of cattle food by feeding animals that can not give an adequate return.
5. By infecting other animals such as calves, swine and other cattle through the milk and by direct contact.
6. By injuring the reputation of the herd, thereby rendering it difficult to dispose of the animals or their products.
7. By destroying the enthusiasm or interest of the breeder in the maintenance of his herd at a high standard.

In reference to the first two of these points it may be said that careful statistics gathered some time ago by Siedamgrotzky in Germany show that the cattle industry of that country was taxed to the extent of 6,762,660 marks per year, as a result of condemnation of carcasses and destruction of parts of carcasses, in slaughter houses; and these figures do not begin to represent the total loss from tuberculosis in that country. Renneberger estimated that the total loss amounted to more than 90,000,000 marks annually. This was considered a conservative estimate. It is recognized that tuberculosis injures the livestock industry in Germany to a far greater extent than any other pest, and this includes such exceedingly virulent affections as rinderpest, lung plague, foot-and-mouth disease, anthrax and others.

"The slaughter-house statistics of Prussia show 14.6 per cent of the cattle and 2.14 per cent of the hogs to be tuberculous. In Saxony the percentage is 29.13 for cattle and 3.10 for hogs. In the city of Leipzig, the figures are 36.4 per cent for cattle and 2.17 per cent for hogs (Siedamgrotzky). Of 20,850 animals in Belgium tested with tuberculin in 1896, 48.88 per cent reacted (Stubbe). Of 25,439 tested in Denmark from 1893

to 1895, 49.3 per cent reacted; and of 67,263 tested from 1896 to 1898, 32.8 per cent reacted (Bang). An examination of 20,930 cattle in Great Britain, either slaughtered and examined post-mortem or tested with tuberculin, showed 5,441, or 26 per cent, affected with tuberculosis. M'Fadyean estimates that 30 per cent of the cows in Great Britain are tuberculous." |||

The amount of tuberculosis found in the food animals by the Government veterinary inspectors in this country is enormous. During the fiscal year 1905, there were inspected 6,134,388 carcasses of beef animals, of which 10,956 were condemned for this disease. The increase of tuberculosis in hogs is shown by the fact that in 1900, of 23,336,884 hogs that were inspected, 5,440 were affected sufficiently to cause a condemnation of some one or more parts of the carcass. In 1905, of 25,357,425 hogs inspected post mortem, 64,919 carcasses and 142,105 parts of carcasses were condemned for tuberculosis. I am told that last year (1911) one packing house lost \$154,000 worth of hogs from this disease. It should be remembered that these condemnations were made on the inspection of hardly a third of the animals killed in the United States for human food. It is also important to note that these inspections were made on animals slaughtered in our larger packing houses and that these animals were in a better general condition than many which are slaughtered locally.

In 1908, Dr. Melvin, Chief of the Bureau of Animal Industry, made the following significant statement at the Congress on Tuberculosis in Washington.¹

"While the saving of human life affords the highest motive for combating tuberculosis, the prevention of financial loss is alone a sufficient reason for undertaking the eradication of the disease from farm animals. Statistics of the United States Federal meat inspection for the fiscal year ending June 30, 1908, covering 53,973,337 animals, or more than one-half of all those slaughtered for food in the country, show the

¹Melvin. Am. Vet. Review, Vol. XXXIV (1908) p. 250.

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following percentage of tuberculosis: Adult cattle, 0.961; calves, 0.026; hogs, 2.049; sheep and goats, 0. The proportion of tuberculosis is probably higher in animals slaughtered without inspection. Reports of tuberculin tests made in the 15 years from 1893 to 1908 by Federal, State and other officers with tuberculin prepared by the Bureau of Animal Industry have been carefully analysed and tabulated. Out of 400,000 cattle tested (mostly dairy cattle) there were 37,000 reactions, or 9.25 per cent. From these two classes of statistics it is concluded that on the average about 10 per cent of the milch cows, 1 per cent of other cattle, and 2 per cent of the hogs in the United States are affected with tuberculosis, the average percentage for all the cattle being estimated at 3.5.

"The accuracy of the tuberculin test has been confirmed in a remarkable way by post mortem examinations. Out of 23,869 reacting cattle slaughtered, lesions of tuberculosis were found in 23,585, a percentage of 98.81. Properly prepared tuberculin applied by a competent person is therefore shown to be a wonderfully reliable agent for diagnosing tuberculosis. In cases where the test appears to give unsatisfactory results, this is usually due to the use of a poor quality of tuberculin or to ignorance or carelessness in applying it.

"The economic loss on account of tuberculosis in food-producing animals is heavy. The loss on animals in which tuberculosis is found in the Federal meat inspection is estimated at \$2,382,433 annually, and if the same conditions were applied to animals slaughtered without Federal inspection the annual loss on all animals slaughtered for food in the United States would be increased to \$3,102,433. The stock of animals on hand is also depreciated in value because of tuberculosis. Assuming that living tuberculous milch cows are annually depreciated to the extent of one-tenth of what the loss would be if they were slaughtered, other cattle one-third, and hogs one-half, the total animal depreciation amounts to \$8,046,219. The annual loss from decrease in milk production is estimated at \$1,150,000, and there also is some

loss from impairment of breeding qualities. Taking all these items into account, the aggregate animal loss because of tuberculosis among farm animals in the United States is estimated at not less than \$14,000,000.

"Such heavy financial losses make the eradication of tuberculosis from farm animals desirable purely as an economic matter."

Sanitary importance. The sanitary significance of bovine tuberculosis has been the subject of many investigations and more or less heated discussions. There is a voluminous literature on the subject but the findings of the last few years have established more definite facts concerning it than the opinions previously entertained.

When Koch discovered the tubercle bacterium to be the specific cause of tuberculosis he believed that the tubercle organisms found in cases of tuberculosis in man and of cattle were identical. This conclusion was supported by many workers on tuberculosis and the belief grew up among not only bacteriologists and physicians but also among laymen that tuberculosis in cattle was transmitted to man. There were those who believed further that human tuberculosis was not infrequently conveyed to cattle. The significance of this belief began to be appreciated after the discovery of tuberculin and the finding of such a large percentage of apparently healthy cattle to be infected. The findings of Smith that there were distinct differences between the human and the bovine varieties of tubercle bacteria showed that there is not so much infection of the human species with the bovine variety of tubercle bacteria as was formerly supposed. His findings, together with the results of many other investigators, seem to warrant the conclusion that adults are rarely if ever infected with the bovine type but that young children suffer to a considerable extent from tubercle infection of bovine origin. Park and Krumwiede² summarized the literature of others together with

²Park and Krumwiede. Collected Studies from the Research Laboratory, Dept. of Health, City of New York, Vol. V (1910).

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their own results relative to the age of the persons infected and the source of the virus. They found from the cases that had been carefully studied bacteriologically that of the 389 tuberculous human subjects 16 years of age or older but 8 were infected with the bovine type. These were in tuberculosis of the abdominal organs, glands and bones. Of 78 tuberculous children between the ages of 5 and 16 years 24 were infected with the bovine variety, and in 136 tuberculous children under 5 years of age 37 were infected with the bovine type of tubercle bacteria. Dr. Park states that from 200 to 300 children die in New York City annually with tuberculosis of the bovine variety. This is a heavy toll to pay for infected milk from a disease that can by a little care be prevented.

Many questions have arisen relative to the possible change in the type of the tubercle organism by passing it through the tissues of different species of animals. A large amount of experimental work has been done along this line. The results tend to show that certain modifications take place in the characteristics of the organisms but that these changes* are not rapid or sufficiently constant to warrant the conclusion that either the human or bovine type is transformed into the other during its passage in the body of the individual. There are, however, some experiments that tend to such a conclusion.

*Park and Krumwiede (*loc. cit.*) have summarized the results of experiments along this line and given the results of their own work. Those who are interested in this phase of the biology of tubercle bacteria will do well to refer to the report mentioned.

CHAPTER III

THE CAUSE OF TUBERCULOSIS IN CATTLE

In 1882, Robert Koch¹ discovered the cause of tuberculosis to be a microorganism which he called the bacillus of tuberculosis. It is a slender rod-shaped organism. It is not motile and it does not produce spores. The more recent classifications of bacteria place this organism in the genus *Bacterium* because of its non motility. In the earlier classifications it was placed in the genus *Bacillus*. It is therefore referred to in the literature on the subject sometimes as a *bacterium* and sometimes as a *bacillus*.

Bacterium tuberculosis appears as a slender rod 1.5 to 4.0 microns* in length and from 0.2 to 0.5 microns in width. The organisms may be straight or slightly curved. As a rule, the curve is more pronounced in the human variety. The diameter is quite uniform throughout its length. In the human variety, especially as found in tuberculous sputum, they are quite frequently beaded and stain somewhat irregularly. The unstained areas are regarded as vacuoles. The bovine variety is slightly shorter than the one from man. It is usually from 1.5 to 3 microns in length and from 0.3 to 0.8 microns in thickness when found in the tissues, milk or excreta. They do not so frequently present irregularly stained areas. A number of observers have found branched forms of tubercle bacteria².

The tubercle bacterium does not stain readily with the

¹Koch. The etiology of tuberculosis. *Mittheilungen aus dem Gesundheitsamte*, Bd. II (1884). Translated by Stanley Boyd and published among the essays by various authors on *Bacteria in Relation to Disease*. In the volumes issued by the New Sydenham Society. London, 1886.

*A micron is a unit for microscopic measurement. It is 1/1,000 of a millimeter or 1/25,000 of an inch.

²Nocard and Roux. *Ann. de l'Inst. Pasteur*, 1887.

ordinary aniline dyes used for staining bacteria. Once stained, however, the dye is retained, even after the application of alcohol and acids. It is for this reason that they are spoken of as "acid proof" bacteria. The chemical analyses of tubercle bacteria show that surrounding the organism or existing in its outer layers or cell wall there are fatty acids. This has given rise to the term "acid fast" as it is supposed that there is some combination between the coloring matter and these fatty acids preventing the bacteria giving up their stain when treated with solutions of mineral acids. The dyes that have been used successfully to stain this organism are Ehrlich's solution of aniline-water gentian-violet and Ziehl's* carbol fuchsin solution. Much found a bacterium resembling that of tuberculosis morphologically but which did not retain the stain when treated with the decolorizing solutions. He refers to it as a non acid-fast tubercle bacterium. In staining *Bacterium tuberculosis*, therefore, the preparation must be first deeply stained and then treated with a solution of a mineral acid such as nitric or sulphuric and thoroughly washed. The tubercle bacteria, if present, will remain deeply stained while the other bacteria and tissues will be decolorized. The preparations may be counterstained with methylene blue, in which case the other bacteria and tissues will be colored. Gabbett combined decolorization and counterstaining in one solution. This consisted of methylene blue 1 gram; conc. sulphuric acid 25 grams; and distilled water 100 cc. After staining in the carbol-fuchsin solution the preparations are covered with this decolorizer for a few seconds and washed

*This consists of

Fuchsin (dry)	1 gram
Alcohol (absolute)	10 cc.
Carbolic acid (5% solution)	100 cc.

Dissolve the fuchsin in the alcohol, after which add the carbolic acid solution. Instead of using the dry fuchsin and alcohol, 11 cc. of a saturated alcoholic solution fuchsin may be used. If the mixture is not clear, add more of the saturated alcoholic solution of fuchsin drop by drop until when viewed through the pipette by transmitted light the liquid is perfectly clear.

in water. The tissues and other bacteria will be stained blue. It has been found that a large number of saprophytic acid-fast bacteria will become decolorized if treated with a 3 per cent solution of hydrochloric acid in 95 per cent alcohol.

Tubercle bacteria are cultivated without difficulty on blood serum, egg medium, glycerin bouillon and potato, after they have been accustomed to artificial cultivation. They are not readily obtained in pure culture from tuberculous tissues. Smith found that by inoculating guinea pigs with the suspected material and as soon as the disease had begun to develop chloroform the pigs and transferring quite large pieces of the diseased organs, such as spleen or liver, directly to the surface of dog serum (coagulated at 72° C.) and placing them in the incubator at 37.5° C. in which there was considerable moisture, the multiplication of the bacteria continues and in some days visible growth appears on the serum at the edges of the tissue. Some workers have little difficulty in the use of ordinary beef serum. The Dorset egg medium is also used by some workers for this purpose.

Growth of tubercle bacteria. On blood serum at 37.5° C., colonies usually become visible at the end of from eight to fourteen days. They appear at first as small, dry, grayish-white, scaly spots with corrugated surfaces. After three or four weeks' cultivation, these join together, covering the surface of the medium as a dry, whitish, wrinkled membrane. Coagulated dog serum is regarded by Theobald Smith as one of the most favorable media for the growth of tubercle bacteria.

Glycerin bouillon (made of beef or veal with peptone one per cent, glycerin 5 per cent, and rendered slightly alkaline) is an extremely favorable medium after it has been cultivated for a few generations on blood serum or egg medium. The bouillon should be in shallow layers, in wide mouthed flasks, as the free access of oxygen is essential for growth. The inoculation of this medium should be made by carefully

floating flakes of the growth upon the surface. In multiplying, the bacteria will spread out upon the surface, at first as a thin, opaque, floating membrane which rapidly thickens into a whitish wrinkled or granular layer, covering the entire surface of the fluid in from four to six weeks. Later, portions of the membrane may sink to the bottom. In old cultures, the membrane assumes a yellowish hue. These cultures emit a peculiar aromatic odor. It is from cultures of this kind that tuberculin is made.

In 1898, Theobald Smith³ published the results of his researches into the relation of human and bovine tubercle bacteria. He found, contrary to all previous statements, that there were well marked morphological, cultural and pathogenic differences between them. In 1901 Koch⁴ read his famous paper in which he gave the world to understand that there was no relation existing between human and bovine tubercle bacteria. With that announcement there began one of the most intense investigations into the nature of a disease that has ever been recorded. For ten years a large number of competent men and women have been carrying on researches covering every conceivable phase of this great malady. The findings are quite unanimous in pointing out two distinct varieties of mammalian tubercle bacteria, one in man, the other in cattle, and in showing that children are sometimes infected with the bovine variety.

The disease producing power of the different varieties of *Bacterium tuberculosis* varies. The human and bovine varieties appear to be equally virulent for guinea pigs. The lesions produced are quite characteristic and can be identified usually by the gross appearance or by microscopic examination of the structure of the changed tissue. The human variety is not usually fatal to rabbits, cattle, or other animals and frequently the tissue changes which it produces are very slight and restricted to the point of inoculation. The bovine

³Smith. Jour. Exper. Med., Vol. III (1898) p. 451.

⁴Koch. Translated in Am. Vet. Review, Vol. XXV (1901) p. 441.

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variety is usually fatal to rabbits and cattle. When fed milk containing tubercle bacteria horses frequently develop tuberculosis.* Swine are very susceptible to the bovine variety. Sheep, goats, cats and dogs are less susceptible although cases of tuberculosis are recorded in these species. The avian variety is virulent for fowls. Moore⁶ was unable to produce tuberculosis in guinea pigs with the avian culture or to produce tuberculosis in fowls with the human and bovine varieties by feeding or by subcutaneous inoculation of pure cultures or of tuberculous sputum or tissue. Both Nocard and Johné, however, report producing the disease in fowls with human and bovine tuberculous tissue. Natural infection seems to take place through the respiratory and digestive tracts. There is a pronounced difference of opinion as to the relative frequency of infection by these channels.

Acid-fast bacteria. In addition to the question of identity or non-identity of human and bovine tubercle bacteria, extended researches have shown the existence of many "acid-fast" bacteria widely distributed in nature that can not be differentiated morphologically or by their staining properties from true tubercle bacteria.

These have been found in considerable numbers in milk, butter, feces, on timothy hay, in water and elsewhere. Peterson⁶ found that the differentiation between tubercle bacteria and certain other "acid-fast" bacteria that frequently appear in the milk and feces of cattle can not be made by the known methods of decolorization such as acidulated alcohol and strong solutions of nitric acid.

Much⁷, and more recently Schroeder⁸, have described non-acid fast organisms that produce a disease in guinea

*In Denmark where horses are given more or less milk, tuberculosis is quite common. We have had one case only of this disease in a horse.

⁶Moore. Jour. Med. Research, Vol. XI (1904) p. 521.

⁶Peterson. Report of N. Y. State Veterinary College, 1909-10, p. 65.

⁷Much. Beitr. z. Klinik der Tub., Bd. IX, S. 415.

⁸Schroeder. Proceedings Am. Vet. Med. Asso., 1911.

pigs with lesions apparently not unlike those of tuberculosis. Thus each of the properties of tubercle bacteria, its supposed specific stain and its effect upon the tissues of guinea pigs, that had long been recognized as possessing diagnostic value, has been found to be insufficient in itself. These findings have brought clearly before us the phenomenon of the "acid-fast" group of bacteria and the difficulty of diagnosing tuberculosis by finding an organism that possesses the right morphology and retains the stain when treated with a de-colorizing reagent.

OTHER PATHOGENIC ACID-FAST BACTERIA

John's disease (chronic bacterial enteritis in cattle). In 1895, Johne and Frothingham⁹ described a chronic disease in cattle characterized by intestinal disturbances and pronounced wasting of flesh and a thickening of the mucous membrane of the affected portions of the intestine. Morphologically, this organism resembles the tubercle bacterium. It varies in size from 1 to 2 microns in length, although individuals of 4 microns have been observed. The bacteria are not particularly intracellular but are found lying free, both single and in chains, in the spaces between the cells and fibers. In old lesions the bacteria are more numerous than in the early stages of the disease.

This was at first thought to be avian tuberculosis in cattle. M'Fadyean¹⁰ has described this disease in England. It has been found a number of times in this country. Olaf Bang¹¹ found that cattle suffering with this disease gave a reaction to tuberculin prepared from the avian variety of tubercle bacteria. They do not react to tuberculin prepared from the human or bovine varieties.

This organism is worthy of careful consideration, as the disease it causes is quite widely distributed in the United

⁹ Johne and Frothingham. Zeit. f. Tiermedizin, Bd. XXI (1894) S. 438.

¹⁰ M'Fadyean. Jour. of Comp. Path. and Therap., Vol. XX (1907) p. 48.

¹¹ Olaf Bang. Ninth International Vet. Congress, The Hague, 1909.

States. It is reported to be quite prevalent on the Island of Jersey. Mr. Olaf Bang of Copenhagen told me recently that when buyers from Denmark bought cattle on that island they tested them with avian tuberculin in order to avoid purchasing animals suffering with this affection.

Stockman¹² has described "acid-fast" bacteria similar to those of Johne's disease, in the intestines of sheep suffering from a like disease. In scrapings from the intestine, bacteria appeared in great numbers and in dense clumps as in Johne's affection. They were also found in the mesentery lymphatic glands. Sections of the glands failed to show any tissue changes suggestive of the formation of tubercles.

Leprosy-like bacteria in animals. The bacterium of leprosy is an acid-fast organism that seems to be somewhat closely related to the tubercle bacterium. In the extent of the bacteria in the diseased tissue Sibley has called attention to the similarity between leprosy and avian tuberculosis.

Dean¹³ investigated a disease of rats in England resembling leprosy in which he found enormous numbers of acid-fast bacteria in the cells which, however, he could not cultivate. This leprosy-like disease of rats was first described by Stefansky¹⁴ in 1903. He pointed out two distinct types, one in which the skin and musculature were involved and the other where the lesions were confined to the lymphatic glands.

Wherry¹⁵ found in a study of the leprosy disease of rats that the organisms were taken up by flies that fed upon the carcasses of the leper rats. He showed that flies thus infected deposited the organisms with their feces. They did not multiply in the intestine of the flies and they were practically eliminated within 48 hours. He experimented with the green bottle fly (*Lucilia Caesar*), blow fly (*Caliphora vomitoria*) and the house fly (*Musca domestica*). He calls attention to

¹²Stockman. Jour. of Comp. Path. and Therap., Vol. XXIV (1911) p. 66.

¹³Dean. The Jour. of Hygiene, Vol. V (1905) p. 99.

¹⁴Stefansky. Centralbl. f. Bakt., Bd. XXXIII (1903) S. 481.

¹⁵Wherry. Jour. of Inf. Dis., Vol. V (1908) p. 507.

the value of rat leprosy in studying the rôle that parasitic insects may play in the transmission of leprosy bacteria.

It is clear that the differentiation of the tubercle organism from the many other bacteria which resemble it in morphology and which retain the stain when treated with decolorizing agents in a manner similar to the tubercle organism, is a far more difficult task than was originally supposed. This calls for greater care on the part of the laboratory worker. The conclusion seems to be justified that there has been more or less of error in the reports of finding tubercle bacteria in various materials when the identification was made on the microscopic examination only. While it is true that the usual methods give in most cases accurate results in diagnosing tuberculosis, the present knowledge of the group of "acid-fast" bacteria demands very careful checking up of methods in all unusual cases or those in which doubt as to the true nature of the organism may exist.

CHAPTER IV

THE NATURE OF TUBERCULOSIS AND THE CHANGES PRODUCED IN THE TISSUES BY TUBERCLE BACTERIA

Tuberculosis is the name given to the condition resulting from the growth of tubercle bacteria in the tissues. The name comes from the Latin *tuberculum* meaning a tubercle which signifies a rounded prominence. In anatomy the term is used to designate a rounded prominence on bone or in soft tissues. In cases of tuberculosis one often finds round smooth prominences protruding from the serous membranes lining the larger cavities of the body. Because of the frequency of the small prominences the Germans refer to this form of tuberculosis as "pearl disease."

Bacteria are known to cause disease in two distinct ways, namely, by producing a virulent toxin that poisons the tissues and by multiplying in the tissues and destroying them. There are many intermediate variations but generally speaking diseases caused by microorganisms are due to the production of toxins or to the destruction of the tissues in which the bacteria are multiplying. Diphtheria and tetanus or lock jaw are good illustrations of the first and tuberculosis and leprosy of the latter method.

All infectious diseases are divided into three quite distinct periods or stages. The first is that immediately following infection and known as the period of incubation. This is the time required for the organisms to become established in the tissues. It is measured from the time they get into the body until the symptoms appear. In most infectious diseases this time varies from a few to fourteen days. The second period is the duration of the disease, that is, the time from the appearance of the first symptoms until death or the beginning of recovery. This time varies from a few days to many weeks, months or years. The third or last period is known

as convalescence and it covers the time from the disappearance of the symptoms until recovery is complete. It also varies in length of time.

In order to have a clear understanding of the kind of disease tuberculosis is, it may be well to compare it with some affection that is more commonly recognized as infectious. For this we may take diphtheria in children. It is well known that diphtheria is caused by a micro-organism, *Bacterium diphtheriae*. It is also known that when a healthy child is exposed (infected) by being brought in contact with a child sick with diphtheria, the period of incubation is but a few days, and that the duration of the disease is short, lasting but a few days or weeks at the longest. At the end of that short period, the entire course of the disease has been run and the child is either dead or well on the way to recovery.

In tuberculosis the periods in the course of the disease differ in detail from those in diphtheria in three very important points, namely, the length of the period of incubation, the way in which the specific bacteria produce the disease, and the time required for it to run its course, or its duration. With diphtheria the specific bacteria produce a toxin which poisons the tissues, and this toxin is the cause of the symptoms, and in fatal cases, of death. In tuberculosis, the specific bacteria do not produce such a toxin, but they live in one or more of the tissues of the body, multiply there, and by their multiplication penetrate deeper and deeper into the organs of the body, destroying the tissues as they go. Finally the injured organs, because they cannot properly perform their functions, give rise to symptoms at first slight, but gradually becoming more and more serious. Death is produced because some organ or part necessary for the life of the individual has been destroyed.* While diphtheria completes its

*In the human subject it frequently happens that secondary infection with streptococci or other septic bacteria is the immediate cause of death. This condition does not seem to occur so frequently in cattle.

course in a few days or weeks, tuberculosis requires for the same purpose months and more often years.

The usual direct anatomical changes following the invasion of tubercle bacteria are the formation of nodules or tubercles. A tubercle has been defined as "a small non-vascular nodule composed of cells varying in form and size with some basement substance between them and with an inherent tendency to undergo central necrosis." In a large number of cases the individual tubercles are distinct and easily recognizable, while in others they are coalesced, forming a mass of necrotic tissue. The lesions vary, therefore, from well isolated minute or larger nodules to masses or cavities containing a purulent, caseous, or calcified substance.

The location of the first or primary lesion depends upon the channel of infection. If the specific organisms are lodged in the mouth or pharynx, they may, through an accidental abrasion of the mucous membrane, be taken to some of the lymphatic glands about the head; if they are taken directly through the respiratory passages into the lungs they either develop nodules in the lung tissues proper, or they are carried through the lymphatic system to the lymph glands draining the lungs where the lesions first appear. If the specific bacteria are first lodged in the mucous membrane of the intestine, primary tuberculous ulcers may develop in the intestine or the bacteria may pass into the mesenteric lymphatics or the portal vein. They may be carried through the thoracic duct into the general circulation and by the blood to any part of the body, such as the brain, liver, kidneys, spleen, testes, ovaries, joints, and subcutaneous and intermuscular glands and serous membranes. The evidence at hand, however, seems to show that in a large majority of cases the first or primary tissue changes are located in one or the other of the five following organs: * (1) in the lungs or the lymphatic glands draining them, (2) in the lymphatic glands about the

*For a detailed study of the lesions in bovine tuberculosis see Bulletin No. 7, Bureau of Animal Industry, 1895, by Theobald Smith.

head, (3) in the mesenteric glands and intestines, (4) in the portal glands or liver substance itself, and (5) in the generative organs and udder.

It not infrequently happens that the apparent primary lesions occur on the pleura, peritoneum, meninges or synovial membranes while the organs remain free from disease. In such cases the lesions consist of many tubercles varying from one to ten or more millimeters in diameter or of bunches of closely set tubercles which are more or less flattened or irregular in shape, owing to their mutual pressure. Sometimes these tubercles are attached to the serous membrane by a small, tough, fibrous pedicle; frequently, however, this is absent and the nodules rest upon the membrane.

The structure of the tubercle. The tubercle consists in the beginning of a few cells surrounding the invading specific organisms. These are soon encased by a zone of epithelioid cells and giant cells which is soon surrounded by an outer layer of round or lymphoid cells. The central portion becomes necrosed and as the nodule enlarges the central necrotic portion becomes correspondingly large. See Plate IV.

This histological structure of the tubercle is typically illustrated in the early stages of the avian tubercle. In most animals there is a tendency to rapid destruction of the tissue but in the fowl the process usually requires more time. In cattle there is a strong tendency for the necrotic tissue to become infiltrated with lime salts. In certain species a deposit of fibrous tissue in the outer zone of the tubercle has been observed. In the smaller and more susceptible experimental animals such as the guinea pig and rabbit and frequently in swine, the lesions are of a more diffuse nature extending into the connective tissue and gradually encroaching upon the cells of the organs. Circumscribed tubercles may also be present.

In secondary or generalized tuberculosis one or more of the organs, such as the lungs, omentum, serous membranes, or lymphatic system, may become more or less thickly

sprinkled with minute grayish nodules about the size of a millet seed. These tubercles are at first almost the color of mother-of-pearl but later as the central caseous degeneration begins they become grayish. Giant cells are usually numerous.

In studying the lesions in a fatal case of tuberculosis one may find with varying modifications one or more of the following conditions:

1. The primary tubercle may be found in any one of the organs or membranes. Its relative age can be determined by the character of the changes and the production of tissue about it. It may be entirely encysted, caseous or dead and calcareous. In addition to the primary focus, there may be a succession of tubercles of various ages distributed in one or more organs.

2. The tubercles may be restricted to one organ, as the liver, in which the primary focus has spread by continuity due to its infiltrating nature until the destruction of the tissues of the organ has become so extensive that death results. Such cases do not seem to be common.

3. The primary lesion may be well marked and accompanied by miliary tubercles sprinkled extensively throughout the organs and tissues of the entire body.

4. The lesions throughout the body may resemble each other very closely, so that difficulty may be experienced in determining the primary focus.

In the lungs, two distinct forms of tissue changes have been observed. (1) The air cells may be infiltrated with the tuberculous mass spreading directly from the primary focus. This may be purulent, caseous or calcareous. The color may be whitish, gray or of a yellowish tinge. (2) The lesions may consist of miliary tubercles. In later stages these nodules, more or less translucent, may become yellowish, caseated, and calcareous in their centers. Large tuberculous nodules are frequently formed by the massing of several of the small tubercles.

When the lungs are primarily affected the large or principal lobes are most frequently involved. Smith considers the seeming predilection for the larger lobes to be due to mechanical conditions. The writer has found, however, that in certain herds that have been killed after the tuberculin test, the primary and only lung lesions of sufficient size to be recognized were in the ventral and cephalic lobes. It is important to note that usually the bronchial glands are also involved. When the serous membranes covering the lungs or intestines are affected, the lesions consist of nodules varying in size from that of a millet seed to a large pea, sprinkled more or less thickly on one or both of the visceral or parietal surfaces. These form the "pearl disease" (*Perlsucht*) of the German and the "grape disease" of the English writers. If they become confluent, large masses are found.

Tuberculosis of the thoracic glands is very common and usually accompanies lesions in the lungs; but the lungs may be healthy and the glands involved. The primary lesions may be and often are found in the lymphatic glands about the head.

In the abdominal cavity the organs most frequently involved are the peritoneum, mesenteric lymph glands, portal lymph glands and liver. The kidneys, spleen, ovaries and uterus are more rarely the seat of tuberculous lesions. Ulcers in the intestine have not been common in the writer's observation. The ulcers in the cases observed have been isolated, with elevated borders and a depressed center. Sections show that the tuberculous infiltration extends outward, and to a certain extent undermines the mucosa. Tuberculosis of the testis is sometimes found. The udder becomes the seat of tuberculous deposits in a small percentage of cases. It is more often affected in cases of generalized tuberculosis.

When the primary infection is restricted to a single focus the disease is said to be localized. When the specific bacteria are spread from the primary lesions through the agency of the lymph and blood streams, sprinkling other organs with

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the infecting bacteria, each of which becomes the starting point for the development of a new tubercle, the disease has become generalized.*

It was formerly considered that when the lesions existed in both of the large (abdominal and thoracic) cavities of the body the disease was generalized. It is possible, however, for it to be generalized when the lesions are restricted to the organs of one cavity, as the secondary seeding with the bacteria that have escaped from a primary focus through the circulation may be restricted to the cavity in which the first lesion developed. It seems better, therefore, to accept Oster-tag's views and classify local and generalized tuberculosis in accordance with the nature of the lesions rather than their distribution in the body.

The fact is worthy of consideration, that very often cattle killed after reacting to tuberculin do not show extensive distribution of lesions. These animals are killed soon after infection has taken place and the lesions may be restricted to a single place such as a lymphatic gland or other organ.

In other cases where the disease is of long standing old lesions of considerable proportion are found. For illustrations of the appearance of tuberculous lesions see Plates V to XXX.

*The Federal meat inspection regulations state that animals affected with "extensive or generalized tuberculosis" are to be condemned. "Evidences of generalized tuberculosis are to be found in such distribution and number of tuberculous lesions as can be explained only upon the supposition of the entrance of tubercle bacilli in considerable number into the systemic circulation. Significant of such generalization are the presence of numerous uniformly distributed tubercles throughout both lungs, also tubercles in the spleen, kidneys, bones, joints, and sexual glands, and in the lymphatic glands connected with these organs and parts, or in the splenic, renal, prescapular, popliteal, and inguinal glands, when several of these organs and parts are coincidentally affected."

CHAPTER V

SYMPTOMS OF TUBERCULOSIS IN CATTLE

With a disease that is usually localized and slow in its development, the symptoms must of necessity be variable and often uncertain. Again, tuberculosis varies in its period of duration from a few weeks or months to many years. More than this, the disease process often becomes arrested and the affected tissues remain until death practically as a foreign body in the diseased animal. It is impossible, therefore, to point out any one symptom or any group of symptoms which will apply to all cases.

The symptoms of chronic tuberculosis depend upon the location of the lesions and their extent. When they are situated deeply and are not of great extent, they may not exhibit visible evidence of their presence. In such cases, the infected animal may present the picture of perfect health and show no disturbance of function. Indeed some animals, in which the lesions are extensive but which have never presented signs of the disease, are slaughtered for beef without a suspicion of the presence of tuberculosis until they are examined post-mortem.

Since the organs affected in tuberculosis vary so much in different individuals, it is not possible to give a description of what can be designated the characteristic or even the usual evidence of this disease. There are, however, certain general manifestations that appear in most of the advanced cases, such as emaciation while the appetite may continue to be good. This is always a suspicious indication and especially if accompanied by cough, rough coat, and tight, harsh skin. Rough or loud respiratory sounds are suspicious, and, in advanced cases, it is often found that the animal groans when pressure is brought to bear upon the chest wall. Hard, painless swellings (enlarged lymphatic glands) beneath the skin

above the udder, in the flank, or in the throat are suspicious.

In tuberculosis of the lungs, coughing is the most noticeable symptom. It is most common after feeding, drinking, or after rapid movement following a period of repose, but sometimes it occurs without any apparent cause. The cough is usually strong, dry and frequently of a high pitch. Sometimes it is very violent, accompanied by protrusion of the tongue. Auscultation reveals modified and abnormal sounds in the lungs such as sibilant, sonorous and mucous rales. A dull sound is often detected on percussion. It is also to be noted that this condition is of slow development and long duration, thus aiding one to distinguish it, in many cases, from bronchitis or pneumonia.

Sometimes large tubercular masses develop on the pleura. In such cases the principal symptom is a friction sound that is heard most distinctly during inspiration. If the masses are large enough they give rise on percussion to a dull sound. In tuberculosis of the stomach and intestines, digestion is interfered with. This gives rise to poor appetite, frequently to diarrhea and sometimes to an alternation of diarrhea and constipation. In tuberculosis of the peritoneum or of the lining of the abdominal cavity, the lymphatic glands of the flank are often enlarged and hard. Sometimes this condition can be diagnosed positively by a rectal examination and the discovery of the hard, nodular masses. Tuberculosis of the liver does not usually give rise to obvious symptoms unless the disease is far advanced, in which case jaundice may be observed.

Where the mediastinal lymphatic glands are enlarged they may press upon the esophagus, causing the animal to bloat habitually. Chronic or habitual bloating accompanied by a good appetite, especially if there is shortness of breath and cough, is indicative of tuberculosis of the mediastinal lymphatic glands. Enlarged tubercular glands along the esophagus may press upon that organ, causing obstruction and preventing the escape of gases from the stomach.

In animals in which the post-pharyngeal lymphatic glands are enlarged from tuberculosis, the breathing is harsh and noisy. In this condition there is sometimes difficulty in swallowing, and particles of chewed up food are occasionally expelled from the mouth, either voluntarily when it is found that they can not be swallowed conveniently, or by the coughing they occasion upon reaching the pharynx. These enlarged glands may sometimes be detected by palpation accomplished by placing one hand on each side of the throat above the larynx and then pressing from opposite sides.

Tuberculosis of the udder is detected by an enlargement and hardening of the affected glands. Usually there is no evidence of pain and the milk secretion ordinarily is not altered until the part has been diseased for some time. In advanced cases, instead of milk, the udder secretes a yellowish, cloudy and sometimes flocculent liquid. In acute, rapidly developing cases, there may be pain and edema of the skin. In nearly all cases of udder tuberculosis the supramammary lymphatic glands situated above the udder in the middle of the escutcheon are enlarged and hard. If there is doubt as to the character of the disease of the udder, the milk, or possibly a piece of excised udder tissue, may be examined bacteriologically.

In tuberculosis of the brain, the animal is unsteady and uncertain in its movements. It lies down much of the time, is usually subject to occasional cramps and is apt to carry the head in an unusual position. Such cases are inclined to advance rapidly and to terminate in death following coma or convulsions.

Occasionally the disease develops in the membranes of the spinal cord causing pressure upon the cord which results in more or less paralysis.

In tuberculosis of the bones and joints, the parts are enlarged; there is loss of motion, pain and usually abscess formation followed by the discharge of a thick yellow pus.

In tuberculosis of the uterus or ovaries and sometimes in

peritoneal tuberculosis of the cow, the subject is almost continually in heat. In tuberculosis of the uterus, there is sometimes a discharge of thick, yellowish material mixed with mucus. In tuberculosis of the testicles the organs become enlarged and hard.

In general tuberculosis, many of the symptoms described above may occur simultaneously.

In all advanced cases, the nutrition of the animal is interfered with and, sooner or later, the "tuberculous cachexia" appears. It is, in many cases, remarkable to note the extent of tuberculous tissues especially on the serous membranes in animals that are well nourished and present no external signs of the disease. Animals killed in prime condition by the butcher are sometimes found to contain extensive and widely distributed lesions of tuberculosis.

The symptoms of acute miliary tuberculosis, "galloping consumption", are rapid loss of flesh, depression, poor appetite, cough, weakness, rapid breathing, harsh respiratory sounds, some elevation in temperature, increased pulse rate and, sometimes, enlarged lymphatic glands. The course of this form of tuberculosis is always rapid and terminates in death. Acute miliary tuberculosis occurs when large numbers of tubercle bacteria are discharged into the blood or lymph currents. They are then carried to other parts of the body, filtered out in the capillaries of the lungs, liver, spleen, kidneys and elsewhere, resulting in the development of tuberculous lesions in each of these localities. The lesion from which the infectious material entered the circulation may have been a comparatively small one. This form of the disease is more likely to appear in young animals than in adults, and is more common among swine than in cattle.

CHAPTER VI

METHODS OF DISSEMINATION

The only way an infectious disease can spread is by means of the germ that causes it escaping from the infected and gaining entrance to the body of the uninfected individual. This leads to a study of three essential phases in the course of the disease and the life history of its virus, namely: (1) How do the organisms escape from the body of the infected animal? (2) What is their fate when expelled from the diseased body? and (3) How do they gain entrance into the body of the sound or well animal? The three questions for discussion therefore are (1) the channels of elimination, (2) the resistance of the virus to external environment and (3) the channels of infection.

As tuberculosis is a specific disease due to a single species of bacteria all questions relating to its spread must be associated directly with the cause. Without this *cause* there can be no tuberculosis. This excludes at once many former theories that poor ventilation, lack of sunlight or the presence of filth was often the cause of the disease and that under such conditions it might start up anew.

Escape of the bacteria. At what time in the course of the disease the tubercle bacteria escape from the infected animal has been a subject of considerable study during the last few years. As the tissue changes of tuberculosis are in most cases localized and as it is known that ordinarily tubercle bacteria are not found in the body of the infected animal except in the diseased part, the question as to when and how they escape has been one that has led to many investigations. In the earlier work the diagnosis was often reached from microscopic examinations of stained and decolorized specimens. This was possible because it was believed that the so-called tubercle stain was specific.

Later investigations have shown that tubercle bacteria obtained from human, bovine, avian, and fish tuberculosis are not the only organisms that take the tubercle stain. It has been demonstrated that there is a large group of bacteria which resist the decolorizing action of mineral acids. These include the bacillus of leprosy, the timothy bacillus of Moeller, the bacillus from butter and cheese described by Rabinowitsch and Petri, the Smegma bacillus, and the organism of Johne's disease. The suggestion that comes from very recent work is that there are many "acid-fast" bacteria which belong to this great group, and which may be mistaken for tubercle bacteria if identified by their staining reaction only.

The following summary of the literature on the finding of tubercle bacteria in milk and excreta was made by Peterson.¹ Anderson² has also given an excellent resumé of the literature on this phase of the disease.

A. C. Abbott and N. Gildersleeve³ have treated extensively of the relation between tubercle bacilli and other members of the acid-fast group. They find among other things, that "the majority of the acid-resisting bacteria may be distinguished from true tubercle bacilli by their inability to resist decolorization by a 30 per cent solution of nitric acid in water." They make a valuable comparison between the lesions caused by tubercle bacilli and those caused by other acid-fast forms. The nodules after intravenous inoculation are seen in the kidneys usually, sometimes in the lungs, but nowhere else. The lesion is localized, there being no progressive destruction of tissue, and tends to terminate in suppuration or organization, not progressive caseation. The bulletin is valuable also because

¹Peterson. Report N. Y. State Veterinary College, 1909-10, p. 65.

²Anderson. Bulletin No. 41, U. S. Public Health and Marine Hospital Service.

³Abbott, A. C., and Gildersleeve, N. The Etiological Significance of the Acid-Resisting Group of Bacteria, and the Evidence in favor of Their Botanical Relation to Bacillus Tuberculosis. Univ. of Penn. Med. Bulletin, June, 1902.

of its complete bibliography on this particular phase of the subject.

An extended comparative study of tubercle bacilli from man and animals was made by Mohler and Washburn of the Bureau of Animal Industry of the United States Department of Agriculture and reported in 1907 in Bulletin 96. In addition to the comparative study reported, in which the conclusion is reached that the various forms of tubercle bacteria are more closely related than is generally supposed, there is appended a resumé of literature on the question of transmissibility from one species of animal to another and to man.

Theobald Smith⁴ examined in 1893 six cows, all of which, except one, showed physical signs of tuberculosis. No statement is made regarding the physical condition of this animal. It was found by animal inoculation that two of the six expelled virulent tubercle bacilli in the milk. The udders were all apparently normal. These two positive cases, however, were so only near the time of death or very late in the course of the disease.

E. C. Schroeder⁵ of the United States Department of Agriculture has written rather extensively on this subject. He announces, as the result of his work, that 40 per cent or more of tuberculous cows expel tubercle bacilli from their bodies in a way dangerous to the health of other animals and persons. Reynolds and Beebe⁶ have obtained results quite contrary to this. Of 45 tuberculous animals examined but one was found to be expelling virulent organisms in numbers sufficient to cause the death of experimental animals. Schroeder places considerable credence upon microscopic findings, while Reynolds and Beebe state that such findings are untrustworthy.

⁴Smith, Theobald. Bur. An. Ind., U. S. Dept. of Agric., Bulletin 3, 1893, pp. 60-66.

⁵Schroeder, E. C. The Unsuspected but Dangerously Tuberculous Cow. Bur. of An. Ind., U. S. Dept. of Agric., Circ. 118.

⁶Reynolds and Beebe. Dissemination of Tuberculosis. Univ. of Minn., Bull. 103.

B. Bang⁷ tested milk from the sound quarter of an udder otherwise tuberculous and found that it contained virulent tubercle bacilli. This investigator⁸ also tested the milk of tuberculous cows whose udders were sound and found 16 per cent positive. G. Stein⁹ tested the raw milk of 14 tuberculous cows. He found ten negative and four positive. Some of the udders were tuberculous. K. Hirschberger¹⁰ found that 11 out of 20 specimens of milk from tuberculous cows contained tubercle bacilli as proved by animal inoculation. He found microscopically only one specimen to contain the organisms. The virulent organisms came from early, advanced and from normal and tuberculous udders. F. Gebhardt¹¹ tested the effect of diluting tuberculous with non-tuberculous milk. When dilutions greater than 1 to 50 were made the resulting mixture was non-pathogenic to experimental animals. He found the market milk of Munich from 10 different sources to be negative.

H. C. Ernst¹² found that 27.7 per cent of the cows whose milk was examined microscopically showed the presence of tubercle bacilli. In all 36 cows were used. He found by animal inoculation that 42.8 per cent of the cows examined were giving off tubercle bacilli in the milk. In this test 14 cows were used. Five out of 12 calves and 2 out of 5 pigs fed with similar milk became tuberculous. Later¹³ he modified the above results as

⁷Bang, B. Deut. Zeitschr. f. Thiermed., Bd. XI, 1884, S. 45.

⁸Bang, B. Experimentelle Untersuchungen üeber tuberkulöse Milch. Deut. Zeitschr. f. Thiermed., Bd. XVII, 1891, S. I.

⁹Stein, G. Experimentelle Beiträge zur Infektion der Milch perlsuchtiger Kühe. Inaug. Dissert., Berlin, 1884.

¹⁰Hirschberger, K. Experimentelle Beiträge zur Infectiosität der Milch tuberkulöser Kühe. Deut. Arch. f. klin. Med., Bd. XLIV, 1889, S. 400.

¹¹Gebhardt, F. Experimentelle Untersuchungen üeber den Einfluss der Verdünnung auf die Wirksamkeit des tuberkulösen Giftes. Virch. Arch., Bd. CIX, 1890, S. 127.

¹²Ernst, H. C. How far may a cow be tuberculous before her milk becomes dangerous as an article of food? Amer. Jour. Med. Sci., Vol. XC VIII, 1890, p. 439.

¹³Ernst, H. C. Article on the Infectiousness of Milk, Boston, 1895. Pub. by Soc. for Promoting Agriculture.

follows: The milk of 36 tuberculous cows with healthy udders was found by animal inoculation to be tuberculous. Five out of 10 pigs and 8 out of 21 calves became tuberculous when fed with similar milk. M'Fadyean and Woodhead¹⁴ found the milk and juice from 14 out of 19 tuberculous udders to contain tubercle bacteria. Two out of 13 cases were positive when the udder was not visibly affected. A. Florentini¹⁵ found three positive cases from tests of milk from tuberculous cows. St. Friis¹⁶ found 14.3 per cent of mixed milk tuberculous. He found country milk¹⁷ entirely negative. E. C. Schroeder¹⁸ in an earlier paper than the one previously mentioned found the milk of 1 out of 12 tuberculous cows positive.

Kuno Obermüller¹⁹ found that 38 per cent of the animals he injected with cream and sediment of centrifuged milk died of tuberculosis. A. Buege²⁰ found two out of six specimens of Halle milk to contain virulent tubercle bacilli. S. Delépine²¹ found by inoculation from 20 to 25 per cent of unmixed milks to be tuberculous. W. E. Hope²² found 5.2 per cent of the milk samples from town dairies and 13.4 per cent from the

¹⁴M'Fadyean and Woodhead. On the transmission of tuberculosis, etc. Internat. Cong. Hyg. and Demog., 1891, Sec 2, p. 197.

¹⁵Florentini, A. Giornale della R. Soc. d'igiene, 1892, p. 198. (Ref. in Baumgarten's Jahresb., 1892, S. 698.)

¹⁶Friis, St. Beitrag zur Beleuchtung der Frage über die Ansteckungsgefahr der Handelsmilch mit bezug auf die Tuberkulose. Deut. Zeitschr. f. Thiermed., Bd. XIX, 1893, S. 115.

¹⁷Friis, St. Fortgesetzte Untersuchungen u. s. w. Deut. Zeitschr. f. Thiermed., Bd. XX, 1894, S. 195.

¹⁸Schroeder, E. C. Further experimental observations on the presence of tubercle bacilli in the milk of cows. Bulletin No. 7, B. A. I., Dept. Agric., 1894, p. 75.

¹⁹Obermüller, Kuno. Ueber Tuberkelbacillenbefunde in der Marktmilch. Hyg. Rundsch., Bd. V, 1895, No. 19, S. 877.

²⁰Buege, A. Ueber die Untersuchung der Milch auf Tuberkelbacillen. Inaug. Dissert., Halle, 1896.

²¹Delépine, S. Jour. Comp. Path. and Ther., Vol. X, pp. 150, 189.

²²Hope, W. E. Report of the Medical Officer of Health, Liverpool, 1897, on tuberculosis as affecting the milk supply of the city.

country dairies contained tubercle bacilli. A. Massone²³ found 9 per cent of the samples of market milk from Genoa tuberculous. Ott²⁴ found 11.1 per cent of market milk samples tuberculous. S. Delépine²⁵ found no tubercle bacilli in the milk from cows showing no evidence of tuberculosis and 27.24 per cent of the milk from cows showing tuberculosis contained virulent tubercle bacilli. He found 5.55 per cent of mixed town milk tuberculous and 17.6 per cent of mixed country milk tuberculous. Petri²⁶ found that 17.5 per cent of the market milk of Berlin was tuberculous. Ascher²⁷ found 1 out of 17 specimens of market milk tuberculous. Jaeger²⁸ examined hospital milk (cows not tested). Two out of six guinea pigs inoculated died of tuberculosis (two died of sepsis). Tubercle bacilli were found in 7 out of 100 cover glass preparations. A. A. Kanthack²⁹ examined the milk from 16 dairies and found that 9 were selling tuberculous milk. Allan MacFadyen³⁰ found that 22 per cent of the samples of milk sent in for examination were tuberculous. Ostertag³¹ found that 1 specimen out of 49 of milk from tuberculous cows which showed no clinical evidence of disease was tuberculous. No tubercle bacilli were found microscopically. Rabinowitsch

²³Massone, A. Annali d'igiene sperimentale, 1897, p. 239. (Ref. in Hyg. Rundsch., Bd. VIII, 1897, S. 605.)

²⁴Ott. Ein weiterer Beitrag zur Milchhygiene. Zeit. f. Fleisch-und Milchhygiene, Bd. VIII, 1897, S. 69.

²⁵Delépine, S. Brit. Med. Jour., Vol. 2, 1898, p. 918.

²⁶Petri. Zum Nachweis der Tuberkelbacillen in Butter und Milch. Arb. a. d. kais. Ges.-Amt., Bd. XIV, 1898, S. I.

²⁷Ascher. Untersuchungen von Butter und Milch auf Tuberkelbacillen. Zeit. f. Hyg., Bd. XXXII, 1899, S. 329.

²⁸Jaeger. Ueber die Möglichkeit tuberkulöser Infektion des Lymph-systems durch Milch und Milchproducte. Hyg. Rundsch., Bd. IX, 1899, S. 801.

²⁹Kanthack, A. A., and Sladen, E. S. St. B. Influence of the Milk Supply on the Spread of Tuberculosis. Lancet, 1899, Vol. 1, p. 74.

³⁰MacFadyen, Allan. Lancet, 1899, Vol. II, p. 849.

³¹Ostertag. Zeit. f. Fleisch-und Milchhygiene, Bd. IX, No. 12, 1899, S. 221.

and Kempner³² found that 71.4 per cent of tuberculous cows gave milk containing tubercle bacilli. Two cows out of 14 tested had udder tuberculosis. Boyce³³ found that 6.6 per cent of town milk examined in 1899 contained tubercle bacilli while 17.4 per cent of the country milk contained tubercle bacilli. Rabinowitsch³⁴ examined eight dairies. Three of these were found to be selling tuberculous milk. Proskauer³⁵ examined Danish and Berlin milk. Thirty-eight and five-tenths per cent of the samples of the former were found to be tuberculous and 55.5 per cent of the latter.

J. F. Anderson³⁶, examining Washington market milk, found that of 223 samples tested 6.7 per cent contained sufficient tubercle bacilli to cause tuberculosis in inoculated animals. Ten and seven-tenths per cent of the 104 dairies examined were selling tuberculous milk.

Peterson, who studied this subject experimentally for more than a year, came to these conclusions:

"The findings in these experiments are significant on the question of the elimination of tubercle bacilli from infected cattle. It is recognized, however, that the number of cattle kept under observation and the time covered by the examinations are not sufficient to throw light upon the question of elimination of tubercle bacilli during the entire course of the disease. The following conclusions seem to be justified:

"The tuberculous cattle examined that were apparently sound but which reacted to the tuberculin test did not eliminate sufficient tubercle bacilli to cause the death of experimental animals when inoculated with their milk or excreta or for the same to be demonstrated microscopically.

"The animals that showed marked physical signs of tuber-

³²Rabinowitsch, Lydia, and Kempner, Walter. *Zeit. Hyg.*, Bd. XXXI, 1899, S. 137.

³³Boyce. (Results given by Annett, *Lancet*, 1900, p. 160.)

³⁴Rabinowitsch, Lydia. *Deut. Med. Woch.*, Bd. XXVI, 1900, S. 416.

³⁵Proskauer, Seligmann, and Croner. *Zeit. Hyg.*, Bd. LVII, 1907, S. 173.

³⁶*Loc. cit.*

culosis eliminated tubercle bacilli in sufficient numbers to be detected microscopically or by animal inoculation in a large percentage of samples of milk and excreta taken at regular intervals. Single examinations of the milk or feces of these cases might give negative results.

"Owing to the frequency of the occurrence of acid-fast bacteria in the excreta and milk of cattle, the microscopic examination for tubercle bacilli is not sufficient to positively determine their presence.

"The mere presence in the circulating blood of virulent tubercle bacilli or certain other pathogenic organisms does not seem to be sufficient to predicate their existence in the milk.

"The differentiation between tubercle bacilli and certain other acid-fast bacteria that frequently appear in the milk and feces of cattle can not be made by the known methods of decolorization such as acidulated-alcohol and strong solutions of nitric acid."

In order to secure information concerning the frequency with which tubercle bacteria escape from occult cases of tuberculosis in cattle and to ascertain the extent of the immediate danger of occult cases to others, a study of the elimination of tubercle bacteria was undertaken in this college early in 1907 and the work is still under way. The first examinations were restricted to single specimens of milk or feces, or both, from cows that had been tested with tuberculin. In some cases the mixed milk of the dairy was taken. As a rule the cows from which the specimens came were free from clinical evidence of disease, but in a few cases symptoms were present. These preliminary examinations were followed by a careful investigation of a series of specimens of the milk and feces taken at short intervals from a smaller number of reacting cows.

The methods employed varied slightly with the conditions under which the milk was received. In all cases it was centrifugalized, and the sediment examined microscopically.

Guinea pigs were inoculated in a number of cases when the microscopic examination suggested that possibly tubercle bacilli were present. In many cases the cream was also examined. The mixed milk came from small and larger herds. The feces were collected after the method employed by Reynolds and Beebe and also those normally passed. The feces were examined microscopically by making properly stained cover-glass preparations from the surface of the normally expelled material, from the scrapings of the rectal mucosa, or from the sediment in centrifugalized specimens. Several preparations were made and examined from each specimen.

In the preliminary work we examined a total of one hundred and thirty-six samples of milk and thirty-six of feces. Of the milk samples, forty-nine were mixed and eighty-seven were from individual cows. Of the latter two had diseased udders. In all, eighty guinea pigs were inoculated. They received two cubic centimeters each of the sediment from the centrifugalized tube. Sixteen of these were injected into the abdominal cavity, the others received the sediment subcutaneously. The results of these examinations were as follows:

Of the forty-nine examinations of mixed milk, tubercle bacteria were found in one specimen microscopically and no inoculations were made. Later experience suggests that possibly these were acid-fast organisms other than true tubercle bacteria. It was not known to us whether or not clinical cases existed in the herds. Guinea pigs inoculated with the mixed milk from two herds developed tuberculosis. It was known that in these herds there were clinical cases. After they were removed subsequent inoculations gave negative results. The guinea pigs inoculated with the samples from the other mixed milk either died within a few days from sepsis or remained well until killed for examination. Thus there were two of the forty-nine samples that contained infecting organisms and possibly the third did also. This gives at the maximum a little over six per cent that contained tubercle bacteria.

Of the eighty-seven examinations of the milk from individ-

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ual cows, tubercle bacteria were not found microscopically or by guinea pig inoculations, except in two cases, and these were samples of milk from the cows whose udders were affected. These were the only cows that showed any clinical evidence of disease and at the time the specimens were taken the lesions in the udders were not thought to be of a tuberculous nature. Tubercle bacteria were present in very large numbers in the milk from each of these cows. They were largely outside of the tissue cells, lying free between the leucocytes and fat globules of the milk. In two specimens acid-fast or timothy bacilli were present in very small numbers. They were decolorized with acidulated alcohol and guinea pigs inoculated from these samples did not develop tuberculosis. If we exclude the two cases in which there were udder lesions, tubercle bacteria were not found in any of the samples. If they were included, a little over two per cent of the examinations were positive.

The thirty-six examinations of the feces failed to reveal the presence of tubercle bacteria either microscopically or by animal inoculation. One specimen contained a few acid-fast organisms. The guinea pigs inoculated from this specimen did not develop tuberculosis.

In drawing conclusions from the results of these examinations, the fact must be kept in mind that they were not made from selected cases, but were made from animals in herds that were tested in regular work. The cows were kept under quite different conditions; some were in the best of sanitary stables and others were not. The number of examinations is too small to warrant any general deductions. The results show, however, that tubercle bacteria were not present or discoverable at least in the milk or feces of a considerable number of specimens taken from reacting and apparently healthy cows. If a careful physical examination had been made and all suspicious cases removed before the bacteriological examinations of the milk and feces were undertaken tubercle bacteria would not have been found either microscopically or by guinea pig inoculation.

As the results mentioned above were obtained from the examination of material from cows in herds that were at the time undergoing the tuberculin test, they were not, except in a few cases, confirmed by further or repeated examinations. They were, however, of the same nature as many of the earlier examinations from which conclusions of a far-reaching significance have been drawn, and upon which certain sanitary regulations have been based. It is to be regretted that in the earlier reports of milk examination for tubercle bacteria the condition of the cows from which it came was not more definitely recorded. In a few cases the statement was made that the udders were apparently free from disease but the possibility of the milk becoming infected from the feces was not so fully considered at that time. It is possible, therefore, that advanced pulmonary lesions or intestinal ulcers, without udder infection, could have been responsible, through fecal contamination, for the bacteria found in the milk.

The results of our single examinations were so strikingly uniform, in that cows with udder tuberculosis were eliminating large numbers of tubercle bacteria with the milk and that cows reacting to tuberculin, but showing no physical evidence of the disease, were not eliminating them so far as we could determine, in either the milk or excreta, that it seemed very desirable to continue the study. It was felt that errors in operation or coincidence might have been responsible for the findings. To overcome these and to ascertain whether or not tubercle organisms appear from time to time in the milk or feces of physically sound but infected cows, it was decided to make a series of examinations extending over a longer period from a smaller number of reacting animals.

In order to have occult cases available for frequent examinations and to have the animals kept under known conditions several tuberculin reacting cows were procured and placed on our veterinary experiment station. They were of grade stock and in good condition. With two exceptions these animals were apparently in a perfectly healthy condition,

although they gave a good tuberculin reaction. The examinations of Nos. 1 to 4 inclusive were begun early in June, 1909, and are still being continued on Nos. 1 to 3. The examinations of Nos. 6 to 12 inclusive were begun in September, 1909, and, with the exception of Nos. 6 and 12, are still being continued. Nos. 5 and 13 were clinical cases and the examinations were made during the latter stages of the disease only. All of the occult cases reacted to tuberculin in February and October, 1910, and again in February, 1911.

The examinations were made as frequently as it was possible. When acid-fast bacteria were found, the preparations were carefully treated with acidulated alcohol or strong (33½ per cent) nitric acid, and one or more guinea pigs were inoculated with the material from each animal exhibiting these organisms. The inoculation of guinea pigs with feces is not altogether satisfactory owing to the considerable number of deaths that occur from sepsis. In this work about thirty of the animals died from this cause. In every case, however, some of the guinea pigs injected with the feces containing acid-fast bacteria lived and were later (four to six weeks) chloroformed and carefully examined.

In order to test further the escape of tubercle bacteria in the milk, the milk from each of the cows Nos. 1, 2, and 3 was fed to two pigs during the months of July, August, and September, 1909. The pigs were examined post-mortem the last of October and in November without finding any evidence of tuberculosis.

In making these examinations the same methods were employed as were followed in the preceding work. The examinations were begun in July, 1909, and continued until January, 1911. Thirteen animals were used in these repeated tests. The work will be continued on these animals until they exhibit physical evidence of the disease or shall have ceased to react to tuberculin. The accompanying table gives the number of examinations that were made from each animal and the results:

NUMBER OF EXAMINATIONS MADE FROM EACH ANIMAL IN THE EIGHTEEN
MONTHS FROM JULY 1, 1909, TO DEC. 31, 1910.

No. of Animal.	Microscopic Examinations.				No. of Animal Inoculations.				Negative or died of Sepsis.	
	No. Samples Examined.		No. of Times Acid-Fast Bacteria were Found in.		Milk.	Feces.	Positive Cases.			
	Milk.	Feces.	Milk.	Feces.			M.	F.		
Cow No. 1.....	79	89	7	32	7	13	0	0	20	
" " 2.....	61	53	10	20	8	3	0	0	11	
" " 3.....	83	93	10	32	7	9	0	0	16	
Bull " 4.....	32	.....	1	0	0	0	0	0	0
Cow " 5 ¹	19	14	2	8	11	4	5	2	8	
" " 6 ²	45	42	6	17	6	1	0	0	7	
" " 7.....	54	61	7	23	2	8	0	0	10	
" " 8.....	Dry	18	.....	10	0	0	.....	.....	.....
" " 9 ³	67	61	6	15	7	8	0	1	14	
" " 10.....	26	60	3	28	1	8	0	0	9	
" " 11.....	37	36	0	14	5	10	0	0	15	
" " 12 ²	20	17	2	5	3	1	0	0	4	
" " 13 ¹	Dry	4	.....	4	0	2	.....	.....	2
Total.....	491	580	53	209	57	67	5	3	116	

¹Cows Nos. 5 and 13 were clinical cases.

²Cows Nos. 6 and 12 were killed in another experiment September, 1910.

³Cow No. 9 developed a cough in October. The positive case was in a guinea pig inoculated in November. The cow is still under observation.

A few examinations of the saliva have been made from each case, but tubercle bacteria were found in that from Nos. 5 and 13 only.

The two clinical cases were of interest. Number 5 was an old cow, exhibiting symptoms of well advanced disease. She was very poor and the supramammary lymph gland was considerably enlarged. When received she ate well. Microscopic examinations of the milk and feces were made and several guinea pigs were inoculated. These, however, were negative. Later she developed a cough, when the sputum and feces were found to contain tubercle bacteria. The enlarged supramam-

mary lymph gland continued to increase in size and after a few weeks the process extended into the mammary gland itself. Soon after this took place the milk contained tubercle bacteria. This was determined by the guinea pigs that were inoculated with the specimens containing these organisms developing generalized tuberculosis.

This cow was killed later and found to be suffering with generalized tuberculosis. There were old and walled-off lesions in the lungs, also a successive series of young and older miliary tubercles. About one-quarter of one mammary gland was tuberculous.

Cow No. 13 was an advanced case of tuberculosis procured to infect a small pasture. She had a bad cough, was thin and not giving milk. The microscopic examination of the feces and expectoration showed acid-fast bacteria, presumably tubercle organisms. The guinea pigs inoculated with the feces died of sepsis, but the one inoculated with the expectoration died of generalized tuberculosis in thirteen days. This cow died before further tests were made. The autopsy showed advanced pulmonary lesions of tuberculosis.

No. 4 was a young bull. He developed evidence of tuberculosis and was killed in the fall of 1909. There were thirty-two examinations of his feces, but they did not reveal the presence of tubercle bacteria. The post-mortem showed lesions in the throat glands only.

Number 9 was an occult case at the beginning of the work in 1909. In October, 1910, she developed a cough and began to grow thin. The guinea pigs inoculated with her milk and feces did not develop tuberculosis until the one inoculated with the feces in November. Inoculations made from the feces after that time gave positive results. The milk still remained uninfected.

Reichel and Deubler³⁷ found in the examination of the feces of forty tuberculous animals that cattle with "open

³⁷Reichel and Deubler. An examination of the feces of forty cattle for tubercle bacilli and conclusions. Journal of Medical Research, XXIV, 1911, 5.

lesions of tuberculosis, and throwing off tubercle bacteria in the feces or rectal scrapings, as a rule show physical symptoms of tuberculosis and are the most active disseminators of the disease." Further they found that "tuberculin reacting cattle do not necessarily throw off tubercle bacteria in the feces, until the development of 'open' lesions of tuberculosis, in which event the condition may be detected by a consideration of the history, careful observation and a complete physical examination."

From the results of these examinations the following tentative conclusions were drawn:

Cows with tuberculous udders eliminate tubercle bacteria with the milk. In such cases the organisms are usually present in large numbers.

Cows with glandular or pulmonary tuberculosis, in which the lesions are discharging into the bronchi, eliminate tubercle bacteria with the feces and with the droolings. In cases of intestinal tuberculous ulcers the organisms are excreted with the feces.

Milk is usually infected with tubercle bacteria when it is taken from cows with tuberculous udders. It may, through contamination with feces or uterine discharges, be infected when drawn from cows with open lesions in the respiratory tract, digestive tract, or organs of reproduction.

Tubercle bacteria are not as a rule present in the milk of cows that react to tuberculin and which on a careful physical examination exhibit no evidence of disease.

The number of tubercle bacteria in market milk would be greatly reduced, and possibly entirely eliminated, by having *frequent* and *thorough* physical examinations of the dairy cows and the removal from the herd of all individuals showing evidence of disease.

The fate of tubercle bacteria outside of the body. The fate of tubercle bacteria after they leave the body depends upon the surroundings into which they are cast. If they are expelled with the saliva and fall upon pastures where direct

sunlight reaches them they soon perish. If they are swallowed and appear in the fecal matter where they are more or less protected from sunlight and drying they will live longer. If they fall on mangers in dark and damp stables they will live for a considerable time. Efforts have been made to determine just how long tubercle bacteria will survive under different conditions but the results are somewhat contradictory and also incomplete. However, dark and damp stables are said to remain infectious for several months.

When tubercle bacteria escape with the milk they may be taken by calves, pigs or children and some of them may gain access to the tissues. Tubercle bacteria do not ordinarily multiply in milk but they will remain alive and virulent in its products for some weeks. There are reports that they remain virulent for a much longer time.

When the lesions that are discharging into the channels of exit such as the intestines are located in the digestive tract or generative organs the specific bacteria escape with the natural discharges. From these, stables often become infected. The fate of the bacteria here depends largely upon the conditions relative to light and dryness.

The channels of infection. Cattle are infected for the greater part through the digestive and respiratory tracts. There is considerable doubt in the minds of certain pathologists as to which of these modes of entrance is the more common. They are occasionally infected through the generative organs.

With these general channels of infection it is not difficult to understand the many possible ways by which tuberculosis spreads. Practically, we have to consider its spread under two conditions, namely: (1) from one herd to another, and (2) from one animal to another in the same herd.

While there are many possibilities for tubercle bacteria to gain entrance to any herd, the usual and practically the only ways by which they are introduced are (1) by bringing infected animals into a sound herd and (2) by feeding unsterilized

separated milk or whey from creameries or cheese factories where the milk from tuberculous cattle is received.

The "buying in" of the disease has been a very common means of infecting previously sound herds. This has been brought about by the purchase of animals in the various stages of the disease. Occasionally farmers have been careless and bought "open" cases of tuberculosis. These rapidly spread the bacteria to other animals in the herd. The diseased animals may be throwing off tubercle bacteria from the lungs; in this case they infect the mangers, stables and perhaps pastures. Watering troughs also become infected with the saliva containing the tubercle organisms. This may remain on the surface of the water where a healthy animal may take it up. Cattle frequently "nose" each other and in various other ways come in direct contact. If the newly purchased animal is infected but is as yet a closed case, it may be weeks, months or even years before it spreads the virus and perhaps it never will. Many herds have become extensively diseased, however, from buying apparently healthy, but infected cattle. Because of the difficulty in detecting temporarily arrested cases, or those that are in the period of incubation, it is not safe to buy from herds in which the disease exists.

Tuberculosis is spread very often through infected creamery and cheese factory by-products. Taking the separated milk from creameries where the milk from open cases of tuberculosis is received to feed calves is one of the most prolific means of spreading the disease. Russell^{**} has published very valuable data on this subject. The infection of calves is a very serious matter as usually they do not show the disease for some time. It often becomes arrested and lies dormant for a variable time. No one can afford to feed calves from a sound herd with the separated mixed milk from a creamery unless he is sure the cattle in the dairies furnishing the milk are free from tuberculosis.

^{**}Russell. Bulletin No. 143, Univ. of Wis. Agric. Exp. Station, 1907.

The spread of tuberculosis is not strange or contrary to the general laws that control the dissemination of pathogenic microorganisms. Because tuberculosis is usually localized and slow in its development, unexpected results are often encountered but they are readily explained. As we have no means of measuring the resistance of any animal to infection and as we can not determine the virulence of the germ in any particular case, the problem is difficult to elucidate but not so hard to understand if we appreciate the law of variation in the course of infectious disease. An active lesion may become arrested, or a dormant tubercle may become active and progress rapidly to a generalized and open case of the disease. The laws of chance may cause an open case to infect in an incredibly short time an entire herd. On the other hand very few animals may be infected from it.

CHAPTER VII

THE DIAGNOSIS OF TUBERCULOSIS IN CATTLE

When the nature of tuberculosis is understood it will be evident that its diagnosis is not always easy. It is not difficult in animals where the disease is advanced but in a large percentage of infected cattle the tissue changes are still so slight that its detection can be made by the use of certain specific methods only. Again it is not always possible for one to be sure even from very suggestive symptoms that the cause of the abnormal condition is tubercle bacteria.

As tuberculosis is very common among cattle, at least in certain localities, symptoms such as coughing, malnutrition, enlarged glands in the throat or elsewhere, or trouble in the udder are very suspicious. There are, however, other causes that will give rise to such symptoms and general appearances and consequently a positive diagnosis can rarely be made from their presence.

The positive diagnosis of a specific disease like tuberculosis is made by one or the other of the following methods, namely:

1. By the character of the tissue changes.
2. By finding the specific germ of the disease in the tissues or discharges.
3. By some specific reaction such as that of tuberculin.

The identification of tuberculosis can be made in most cases from the tissue changes, where the affected part can be removed from the animal, when they are sufficiently advanced and not modified by secondary infections. Microscopic examination is of much assistance in cases where the tubercles are small and exhibit the somewhat characteristic cell arrangement. There are, however, cases of tuberculosis where the lesions are atypical and which can not be diagnosed by their gross or microscopic appearance. In these cases it is clear that some specific method of diagnosis must be applied.

From the description of the location and nature of the tissue changes in animals affected with tuberculosis it is clear that the diagnosis must be based on the lesion rather than on its location in the body. It is also true that most of the tissue changes are beneath the surface of the body so that they can not be removed for examination. If, however, the affected area can be removed from the living animal as in case of certain enlarged glands, or if the diseased tissues are taken from the dead animal, an accurate diagnosis can be made from their gross or microscopic appearance in a very large percentage of cases by one skilled in the nature of the tissue changes.

The bacteriological examination was availed of for diagnosis as soon as the tubercle bacterium was discovered. This consists first in finding the organism in the tissues by a microscopic examination. This has been made possible by the tubercle stain. It was thought for many years that this method was a means of diagnosis and that the presence of "acid-fast" bacteria was sufficient to make a positive diagnosis. More recently it has been shown that non-pathogenic "acid-fast" bacteria resembling tubercle bacteria very closely are occasionally found in excreta and more rarely in milk. This discovery has rendered a positive diagnosis by microscopic examination alone very difficult, in fact it is impossible in certain cases especially of the excreta. Cases seem to be rare where the non-pathogenic forms can not be differentiated from tubercle bacteria by means of the decolorization with acidulated alcohol. There are some cases, however, where this is impossible.* Nevertheless the bacteriological method is of great assistance.

In using the microscopic examination for bacteria it is very important to recognize that tubercle bacteria are not present in any excreta, or in the milk in case of udder tuberculosis, until the tissue changes have advanced sufficiently to enable the bacteria to escape. In the examination of dead

*Peterson (*loc. cit.*) found several cases of this kind.

tissue from old lesions it is often impossible to find the organisms by this method.

Animal inoculation. A more reliable procedure is to inoculate guinea pigs subcutaneously with the suspected material. If it is tuberculosis the guinea pig will develop the disease and die of tuberculosis usually in from three to six weeks. From the dead guinea pig the disease can generally be determined from the appearance of the lesions but a microscopic examination of the affected organs (liver, spleen or omentum) will usually reveal the presence of tubercle bacteria. If desired, cultures may be obtained from the fresh tissues. It often happens that the presence of the bacteria can be determined by this method when the microscopic examination alone would be negative.

Tuberculin. The most reliable means of diagnosis in the living animal is by the use of tuberculin. The subcutaneous injection is the most certain method of using it although other methods such as the conjunctival and intradermal use have certain advantages.

The difficulty in diagnosing tuberculosis with tuberculin rests in two conditions: first the interpretation of the tuberculin reaction when the rise of temperature is slightly above normal, and secondly when there is no reaction in certain individuals in infected herds. (See chapter VIII.)

The positive diagnosis of tuberculosis in all infected animals is not an easy task. In many cases, it is impossible by any method known at the present time to tell whether an animal that has been exposed to an open case of the disease (an animal that is giving off tubercle bacteria) has become infected.

There has been too much confidence in the infallibility of methods for diagnosis. The symptoms, the tissue changes, the examination for the specific bacteria and the reaction of tuberculin are all valuable and the last two may be considered positive when the organisms are found or when the tuberculin gives a recognized reaction. But when the specific bacteria are not found and the tuberculin does not

cause a reaction we can not be so sure that infection does not exist. There is a limitation to the diagnostic information that can be acquired by the use of any of the known methods or reactions used in the diagnosis of tuberculosis.

Unfortunately for the veterinarian, the owner or the purchaser, the negative findings are not conclusive while the positive ones are. Experience has shown that in large herds when a high percentage of the animals react to tuberculin more or less of the others are infected. The International Tuberculosis Commission recommended that when 50 per cent of a herd reacted to tuberculin the entire herd should be considered tuberculous.

CHAPTER VIII

TUBERCULIN AND ITS USE

Tuberculin is the liquid (usually glycerinated bouillon) on which tubercle bacteria have grown until it has become saturated with the product of the organisms. The term tuberculin seems to have first been used by Bujwid for the name of the preparation made from cultures of tubercle bacteria from which the organisms had been removed. This substance was first discovered by Robert Koch in 1890. It was called by him "lymph" and it was known as the Koch "lymph." Later Koch accepted the term tuberculin and applied it to his preparation.

Since Koch first discovered tuberculin a number of other substances have been obtained from tubercle bacteria by other workers and given different names. Thus we have "Tuberkulocidin" of Klebs and the "*New Tuberculin*" prepared by Koch from the bodies of the living, unheated tubercle bacteria. There are a large number of other preparations of tuberculin made by some modification of the original method. The old tuberculin, or Koch "lymph", is often spoken of as "TO" and the New Tuberculin as "TR". The first consists of the liquid cultures after the removal of all of the tubercle organisms and the second, or New Tuberculin, is composed of an aqueous extract of the ground or crushed bodies of the living tubercle bacteria themselves.

The Koch "lymph" or tuberculin was thought when first discovered to possess marked therapeutic properties. There are many who still maintain that it is of great value in the treatment of certain cases of tuberculosis.

Experiments with tuberculin as a remedy for tuberculosis of cattle were made by Pearson in 1892, and were reported in the "Proceedings of the First International Veterinary Congress of America" in October, 1893. These experiments were

made upon cows, and showed that the general effect of tuberculin on a tuberculous animal was to cause the disease to pursue a chronic course, or, in some cases, to become latent, but not to disappear.

These and other experiments with tuberculin as a preventative and also as a cure for tuberculosis of animals were made during several years following Koch's discovery. It was at last established that while tuberculin has a specific effect upon the lesions of tuberculosis, and perhaps in some cases causes the lesions to become encapsulated, this effect is by no means constant, nor is it sufficiently frequent to render this treatment of practical value.

The real value of tuberculin to the veterinarian and to the dairyman lies in its diagnostic properties. The new tuberculin (TR) was believed to possess immunizing properties, but experience has shown that it can not be recommended for that purpose other than experimentally.

The Committee of the American Public Health Association¹ on standard methods for the preparation of tuberculin recommended that the following points be observed in its preparation. These recommendations are followed fairly closely by all those who are preparing it in this country.

"The medium shall consist of bouillon prepared from meat (veal or beef) and not meat extract. The bouillon shall contain 1% peptone (Witte's), 0.5% sodium chloride or acid potassium phosphate, chemically pure glycerine 5% (this may vary from 3 to 7%). The final reaction of the bouillon shall be 0.75 to 1.0 to phenolphthalein, the normal acidity of the broth being corrected by the addition of sodium hydrate solution.

"The culture of tubercle bacterium employed shall be of mammalian origin and shall produce an active tuberculin.

"The containers in which the cultures of tubercle bacteria are grown shall be in form similar to the Erlenmeyer flasks

¹Am. Jour. Public Hygiene, Vol. XX, No. 3, Aug. 1910.

of the Jena pattern, preferably 300 c.c. capacity, each flask to contain 100 c.c. of bouillon.

"The cultures should be allowed to grow for four weeks after the surface of the medium is completely covered with the growth of the tubercle bacteria.

"In the preparation of the tuberculin the ripe cultures are shaken down, placed in a steam sterilizer and subjected to live steam for at least $2\frac{1}{2}$ hours, filtered through paper, and evaporated to one-tenth of original volume. Before being supplied to practitioners the tuberculin should be passed through Chamberland or Berkefeld filters.

"Tuberculin should be sent out from the laboratory so that the practitioner need not dilute it before using. The dilutions when exposed to the air should not for human practice be prepared for any great length of time before use. The dilutant suggested is 0.25% phenol in physiological normal salt solution."

The technique for preparing tuberculin is as follows: The tubercle bacteria are grown in pure culture at a temperature of about 37.5° C. (99.5° F.) on a liquid medium consisting of beef tea containing peptone (about 1%) and glycerin (from 5 to 7%). In some laboratories a little acid potassium phosphate is added. This glycerinated peptonized bouillon is put in flasks. Usually from 100 to 250 c.c. are put in each flask. After it is sterilized it is inoculated with tubercle bacteria by transferring some of the growth from a young culture to the surface of the liquid in the flask. These bacteria do not grow in the depth of the liquid, but form a membrane over the surface. After the cultures have grown for a sufficient length of time, which varies from four to ten weeks, the flasks are placed in a water bath and heated to a temperature of from 55° to 65° C. for about two hours, after which they are boiled. After boiling, these cultures are filtered through ordinary filter paper to remove the mass of bacteria. The filtrate is then evaporated over a water bath to the desired consistency and is then filtered through a porcelain or Berkefeld filter.

In some laboratories it is filtered through the porcelain filter before it is concentrated. See Plate III.

The original Koch tuberculin was evaporated to one-tenth the volume of the culture liquid, i. e., 100 c.c. of the culture liquid was evaporated to 10 c.c. and a little carbolic acid ($\frac{1}{2}$ of 1 per cent) added to the filtrate to preserve it. It is kept in glass-stoppered bottles.

It has been found that either the human or bovine variety of tubercle bacteria can be used in the preparation of tuberculin. It has also been found that occasionally a culture of tubercle bacteria is obtained which will not produce a satisfactory tuberculin. The active principle in tuberculin is believed to come from the bodies of the tubercle organisms that have become macerated in the culture fluid.

Application of tuberculin. Although tuberculin has been employed for a number of years as a diagnostic agent for detecting tuberculosis in cattle, methods for its application do not seem in general to be fully understood. Although its application is simple in detail, it is very important that all the conditions attending its use should be observed.

Tuberculin should not be applied to an animal that is suffering from any other infectious disease or any abnormal condition, giving rise to an elevation of temperature, or to an animal that is far advanced in pregnancy. The reason for not testing a cow advanced in pregnancy is because animals in that condition have sometimes been reported to give a rise of temperature following the injection, when they are not tuberculous. This has not been the experience of the writer.

The animals to be tested should be kept under perfectly normal conditions with the possible exception that it is necessary to keep them up in stables rather than to allow them to run in a pasture. Before injection, the temperature of the animals should be taken. It is recommended that the temperature be taken every two hours for four to six hours preceding the injection of tuberculin. Some of the official regulations require three temperatures taken at intervals of two

hours before injection. The real purpose of taking these preliminary temperatures is to ascertain whether the animals have an abnormal temperature or not*. If the temperature is abnormal the animal should not be tested at that time.

The tuberculin is administered subcutaneously. It is usually injected under the loose skin in the neck or in the axilla. In its application, it has been found advantageous to reach over the animal and apply it on the opposite side. Care should be taken that the syringe is sterilized. It has been advised that the skin of the cow at the point of injection should also be disinfected. This is a safe precaution; but the difficulty of disinfecting the skin quickly and the infrequency with which cattle become infected with skin organisms suggest that this precaution is not necessary. After the syringe is sterilized the recommendation of Dr. Law seems to be a good one, namely, to insert the needle in pure (liquid) carbolic acid between each two injections. This destroys any organ-

*In cattle there is occasionally considerable variation in the body temperature within 24 hours. Cold water, when drunk in considerable quantities, lowers the temperature from 1 to 3°. A temporary excitement may cause an elevation of from 1 to 1.5°. There are often marked variations in the temperature of the same animal on consecutive days. The temperature at 12 noon and 12 midnight is often the same. In some cases the maximum elevation occurs near midnight, and on the following day the minimum temperature will be recorded at that time. It is not uncommon for a maximum temperature to occur twice a day and occasionally several times within the twenty-four hours. There are marked individual variations in the effect of ordinary conditions, such as food, excitement, and temperature of the air, upon the temperature of the animal. A hot spell (temperature 90° F.) may cause a rise of 2° and even 4°. The average temperature of the animals in three herds tested was 102.5°, 102.6° and 101° F. respectively. In a well-kept government herd that was tested with tuberculin the temperature of part of the animals was taken hourly for twenty-four hours preceding injection. An examination of the records (Bulletin No. 7, Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C., 1894. The tests were made under the direction of Dr. Theobald Smith by Drs. F. L. Kilborne and E. C. Schroeder) shows the average daily variation of twenty of these animals to be 2.31° F. The maximum individual variation in a single day was 4.3° F., the minimum 0.5° F.

isms that might become attached to the needle in withdrawing it from one animal, and the acid that adheres to it seems to be sufficient to prevent the introduction of living organisms when the needle is inserted into the next animal.

The dose. The dose of tuberculin ordinarily given to an adult animal of medium size is 0.25 c.c. of the Koch tuberculin. The tuberculin from the laboratories in this country is usually sent out already diluted, so that 2 c.c. is the dose. The quantity to be given is almost always marked on the bottle. It represents as nearly as possible 0.25 c.c. of the concentrated Koch tuberculin. In administering it some veterinarians have emphasized the importance of still further diluting it, so that 5 c.c. is injected instead of 2 c.c. The purpose of this is to minimize the loss of the tuberculin which necessarily adheres to the dish and syringe. The exact dose, i. e., the one that gives the best reaction, has not been determined. It has been stated by a few workers that a much smaller quantity will give a diagnostic reaction, but that the rise of temperature does not occur until after a much longer time has elapsed. When applied to young or very small animals or to very large ones the dose should be regulated accordingly.

Beginning six or at the latest eight hours after the injection, the temperature of the animal should be taken hourly, or at least every two hours, for eighteen hours after the injection, that is, five temperatures at intervals of not more than two hours. If at the end of this time the temperature of any animal appears to be rising it should be taken again and repeated at like intervals until it returns to the normal. In taking temperatures it is recommended by some to lubricate the thermometers with vaseline.

During the time that the test is being made the cattle should be kept quiet, free from all exposures or excitement, and fed and watered as usual. The water should not be too cold.

Reaction. The usual reaction consists in a rise of temperature, beginning about the sixth or eighth hour after injection

and continuing for several hours. The rise varies from 1° or 1.5° to 4° or 5° F. above the normal. A reaction, however, does not mean simply a rise of temperature for a brief time, but a gradual rise, a continued high temperature for a few (2 to 6) hours and then a gradual decline. This is called the tuberculin curve. It is more important in the interpretation than the simple rise of temperature. Formerly official regulations for testing cattle called in case of a reaction for a certain rise of temperature above the highest preliminary temperature. At first it was thought that there should be a rise of at least 2° F. Later, 1.5° F. was considered a reaction. It is the writer's belief, after the careful examination of many tests and the making of many post mortems following tuberculin injection, that a slight rise may represent a reaction. When the maximum temperature ranges from 103.5° F. down to 103° F. or even to a few tenths of a degree less, the cases are suspicious if the curve is well marked. When animals with such temperatures are slaughtered from 40 to 60% of them usually reveal tuberculous lesions. With our present knowledge one can not be positive of a reaction with a temperature curve having a maximum of less than 104° F. but all cases in which the subsequent temperature ranges between 103° and 104° F. should be considered suspicious. A large percentage of animals giving such temperatures that have been slaughtered have proven to be tuberculous. There are a few cattle owners who exclude from the herd animals that give a temperature even lower than 103° F. following the injection of the tuberculin if there is evidence of a gradual rise and decline.

In many animals there is an organic or constitutional reaction which consists in roughening of the coat, evidence of chill, dullness of the eye, indifference to food and a general depressed appearance. In the writer's observation this has happened in a small percentage of cases. The testimony of others indicates that it may be more frequent. In milch cows, in case of reaction there is some shrinking of the milk, due probably to the rise of temperature. In cows that do not react

the effect upon the flow of milk is slight, if any at all. When the test is made in summer and the cattle are taken off from pasture for this purpose and fed hay, there may be some diminution in the milk owing to these conditions.* It is possible that excitement may have some influence.

How does tuberculin act? The use of tuberculin has demonstrated three distinct and interesting phenomena: First, a marked sensitiveness of the tuberculous individual and a comparative indifference of the healthy body to it. Second, a distinct thermal reaction of the tuberculous individual, that is, a general effect. Third, a hyperemia of the tuberculous focus. These can be demonstrated in the tuberculous guinea pig. The extent of the hyperemia of the tuberculous focus in cattle does not seem to be so marked as it is in the infected guinea pig. The explanation for the rise of temperature in the tuberculous body following the injection of tuberculin is not easy to determine. A number of explanations have been offered for the action of tuberculin¹, but the one first suggested by Eber² some twelve years ago and modified slightly by Theobald Smith³ seems to meet the conditions better than any of the others. It is as follows:

"In the tubercular tissues and their immediate vicinity the tubercle bacteria have induced certain tissue changes, and with them certain new functions of the tissue have been aroused which are the result of immunization. These new properties

*Gilliland has made a careful study of the effect of tuberculin on the flow of milk. He found it has no effect on the flow of milk from non-reactors and the slight shrinkage in those that react was attributed to the rise of temperature. Proceedings Am. Vet. Med. Asso., 1907.

¹Citron (Berliner klin. Wochenschrift, 1907) expresses the opinion that the reaction to tuberculin consists in the multiplication of sessile cell receptors and free antibodies at the focus of infection, after which the latter disappear. He states further that in the last stage of the reaction there are numerous fixed cell receptors and free antibodies in the tuberculous foci and in the serum.

²Eber. Deutsche Zeitschrift für Tiermedizin, Bd. XXI, S. 34.

³Smith. The Harvey Lectures, 1905-6, p. 272.

are concentrated in the immediate neighborhood of the focus. The specific resistance is, as it were, chiefly focal and only secondarily generalized. When the tuberculin comes in contact with the focus, the former is acted on, with the result that the originally innocuous tuberculin becomes poisonous perhaps by the splitting off of some poisonous substance. An incomplete digestion I should prefer to call it. As a result of this action we have, first, the local hyperemia and, second, the constitutional effect. In other words, the tuberculin becomes poisonous by an immune reaction directed toward the tubercle bacillus. This reaction is defective and in so far dangerous to the host. The only way in which the danger can be met is for the body to produce an antibody to this second substance. So far there is little evidence to show that the body is able to produce this in any amount. The animal body has learned to protect itself by suppressing multiplication rather than by attempting to neutralize such poisons."*

The interpretation of the reaction. When a typical tuberculin reaction occurs the interpretation of it is that the animal is suffering from a tuberculous infection and that most likely the process is more or less active. This reaction may occur when the tuberculous focus is very small, in fact, it is possible that it should take place when the specific lesions are still microscopic in size. In most post mortems, however, the bones, spinal cord and brain are not examined; and we know tuberculosis becomes localized in these organs in a certain number of cases. It is possible that in those individuals where reaction takes place and where no evidence of the disease is found in a gross examination of the viscera, a more careful examination of the organs, intermuscular and subcutaneous tissues, as well as of the bones and nervous system, might reveal the presence of macroscopic lesions. Tuberculous lesions have occasionally been found in bones, especially ver-

*This secondary poison is probably of the same nature as the aggressins recently brought forward by Bail.

tebrae and joints, and in the membranes covering the brain and spinal cord.

In cases where there is no reaction the interpretation is more difficult. Formerly the assumption was that tuberculin will cause a reaction in all infected animals, and that if the animal does not react it is free from infection. But tuberculin does not give a reaction during the period of incubation. It does not give a reaction in most if not all cases where the disease has become arrested, encapsulated or healed.*

It is stated on good authority that tuberculin does not give a reaction in certain cases where the disease is very far advanced. A number of veterinarians have reported cases of cattle that gave no reaction following the injection of tuberculin, but which on slaughter and post mortem were found to be very extensively diseased. Dr. Wills, of the N. Y. State

*In certain herds where the Bang method has been applied the results have been quite different respecting the original non-reacting animals. In one case where there were 17 reacting and 13 sound individuals, but one of the 13 subsequently reacted, although tested semi-annually for four years. In other herds a much larger percentage of the supposed sound animals reacted on subsequent tests.

In a large herd of cattle tested there were 96 cows that did not react. These were placed by themselves in a practically new barn, and three months later, and every six months thereafter, the sound herd was tested. Those that responded were promptly removed and the stable was thoroughly disinfected with a 5 per cent solution of carbolic acid after each test. The results of the consecutive tests of the non-reacting animals are exceedingly instructive. They are as follows:

1904.	July.....	96	tested;	31	reacted,	65	did not react;	32.2%	reacted.
1905.	Jan.....	65	"	8	"	57	"	"	12.3
	July.....	57	"	15	"	42	"	"	26.3
1906.	Jan.....	42	"	15	"	27	"	"	35.7
.	July.....	27	"	3	"	24	"	"	11.1
1907.	Jan.....	24	"	2	"	22	"	"	8.3
	July.....	22	"	1	"	21	"	"	4.5
1908.	Jan.....	21	"	1	"	20	"	"	4.7
	Aug.....	20	"	1	"	19	"	"	5.0

During this time the non-reacting animals were kept by themselves. There was no opportunity for infection after they were removed from the

Department of Agriculture, has furnished me with several cases of this kind. The fact should not be overlooked that such animals are *obviously diseased* and would be rejected on physical examination. The explanation as to why certain very advanced cases do not react is not altogether clear.

Limitations of tuberculin. The limitations to the action of tuberculin when applied to infected cattle are: (1) when the disease is in the period of incubation; (2) when it is arrested; and (3) in certain cases where the disease is very advanced.

The records of tuberculin tested herds do not necessarily always point out all the animals in the herds that are infected, or those which may subsequently develop an active form of the disease. The recently infected and latent cases cannot be detected until the disease becomes active. To catch them early requires repeated tests. It is not known how long the lesions may lie dormant, but we have individuals where they sprang into activity after three and one-half years, and also a case where an apparently healed, calcified tubercle contained living virulent tubercle bacteria three years after the cow ceased to react. It is such cases as these that have caused

original herd, except possibly from those that reacted from time to time. Several of the reactors were examined post mortem. The lesions were as a rule slight in extent, but of long standing. They were surrounded by a wall of fibrous tissue. The explanation is that these animals were infected while associating with the diseased cattle, some of which were eliminating tubercle bacteria, and that the lesions had become arrested before the first test was made. The repeated tests of the reacting animals in the same herd support this hypothesis. The second test, made three months later, showed fully 25 per cent not to react. Several of these continued not to respond, while others reacted again later. This oscillating of the morbid process between an active and an arrested condition is an important factor in considering the future of the supposed healthy animals and in interpreting the tuberculin reaction.

The value of tuberculin in detecting tuberculous infected cattle is indispensable in examining cows to be purchased. If they fail to react, and they come from infected herds, it is very necessary that the test be repeated. Experience has shown that when a herd becomes extensively infected (50 per cent or more reacting), a considerable number of the non-reactors are suffering from latent or dormant tuberculosis, which may become active later.

tuberculosis to reappear in many herds after the reacting animals have been destroyed. The owners of such herds are inclined to blame the tuberculin or the man who used it. The fault is not with the tuberculin or with the person who applied it, but in the failure to have subsequent tests made.

There is great need for more investigations into the failure of tuberculin to react in arrested cases. It is very important to know about what percentage of infected cattle have the disease in the latent form and also to determine when in the process of healing the tuberculous foci will not respond to tuberculin. The report of Carini⁴ that there are about 17% of infected cattle that do not react seems larger than our experience indicates. These are matters of great importance to take into account in the interpretation of the negative results, especially in cattle that are in badly infected herds. It will probably be demonstrated that the extent of the infection in the herd will be a safe guide in the estimation of the number of arrested or healed cases among the non-reactors. There seem to be no data on the frequency with which infected cattle recover. It is believed that such cases are more numerous than has heretofore been supposed.

The skin and ophthalmic tests. It has often been noted, especially in the human subject, that a considerable degree of local irritation occurs at the site of the injection of tuberculin

⁴Carini. Arch. wiss. u. prakt. Tierheilk., 1906, p. 562.

The failure to recognize this fact has caused the disease to reappear in many herds where the reacting animals from the first test had been destroyed. This is illustrated from the following observation:

In July, 1906, a dairyman purchased 92 cows from a tuberculous district on the tuberculin test. They were tested every six months thereafter. They were kept by themselves for a year, and were not exposed to known infected cattle after their purchase. The results of the subsequent tests were as follows:

1907.	Jan.....	92	tested;	0	reacted.
	June.....	92	"	3	" 89 did not react; 3.3% reacted
1908.	Jan.....	89	"	24	" 65 " " 26.9 "
	Aug.....	65	"	4	" 61 " " 6.2 "

on tuberculous patients. The significance of this phenomenon was not fully appreciated until the investigations of von Pirquet⁵ on so-called accelerated reactions in revaccinations against smallpox. This condition recalled the well-known experiments of Koch which led to the discovery of tuberculin: namely, that in a tuberculous guinea pig a second inoculation under the skin was followed by much more swelling than the first and a rapid formation of a slough without involvement of the surrounding lymph nodes as in the primary infection. Von Pirquet's attention was directed, in consequence of this, to the effect of tuberculin rubbed into scarifications on the skin. In 360 tests in children in the Berlin and Vienna clinics it was found that a well-marked difference was obtained in the reaction hyperemia between tuberculous and non-tuberculous children under two years of age, but in older individuals this was slight. The diagnostic value, therefore, seemed to be limited to children. This method was tried by Arloing⁶ and Vallée⁷ in cattle, rabbits and guinea pigs, with somewhat uncertain reactions produced in the scarifications.

In order to overcome the danger of injecting too much tuberculin in making a diagnosis on the human subject a method was simultaneously proposed by Calmette⁸ of Lille, France, and Wolff-Eisner⁹ of Berlin. The method consists in putting a drop of weak tuberculin solution (1%) into the eye, whereby a conjunctival hyperemia is produced in tuberculous individuals. This is due to the increased sensitiveness of the tissue of tuberculous as compared with non-tuberculous persons, who should exhibit no signs of irritation from the same procedure. The recent tests of this method in the human subject have given a variety of results and reactions have been obtained in a considerable number of individuals who appeared

⁵Von Pirquet. *Berliner klin. Wochenschr.*, May 20, 1907.

⁶Arloing. *Comptes Rendu de la Soc. de Biol.*, June 28-29, 1907.

⁷Vallée. *Ibid.*, July 12, 1907.

⁸Calmette. *Presse Médicale*, June 19 and July 13, 1907.

⁹Wolff-Eisner. *Berliner klin. Wochenschr.*, June 3, 1907.

to be perfectly healthy and who had no history of tuberculous infection. The view has been expressed that this reaction may take place in healed cases of tuberculosis, due to the fact that the conjunctiva and possibly skin have been sensitized by some previous infection, however slight. If it is demonstrated that this reaction occurs simply as the result of anaphylaxis it would not indicate the presence of active tuberculosis.

In this method a modified tuberculin is used* to avoid the irritating effect of the peptone and other foreign substances that are present in the bouillon from which the old tuberculin is prepared.

This method of applying tuberculin has been tested in cattle by a number of workers, but as yet it is not generally considered to be satisfactory. McCampbell and White¹⁰ have published their results with it. Their procedure was as follows:

"The method first tried was the administration of the tuberculin as prepared by Calmette. A one per cent solution was made by dissolving the precipitate, obtained by treating tuberculin with absolute alcohol, in sterile water. The solution was sterilized by steam at 100° C. One-tenth (0.1) to one-fifth (0.2) cubic centimeter of the above solution was placed in the conjunctival sac of each cow. No results were obtained by the use of this method. There is a possibility that the amounts used were too small.

"The tuberculin which proved to give the most successful results was procured from the Bureau of Animal Industry, United States Department of Agriculture. It was used full strength and twenty-five hundredths (.25 c.c.) of a cubic centi-

*This is prepared by precipitating the active principle from the old tuberculin by means of alcohol, then obtaining definite solutions of $\frac{1}{2}$ to 1% of the dry powder in sterilized normal salt solution. A drop of this solution is put in the eye. In the human subject various strengths have been tried and are used.

¹⁰McCampbell and White. The ophthalmic-tuberculin reaction in cattle. The Jour. of Experimental Medicine, Vol. X, No. 2, 1908, p. 232.

meter was placed in the conjunctival sac of each cow with a sterile eye dropper. The right eye was used, its condition being noted and compared with the left at the time of injection. Accurate data were recorded in regard to the temperature before and after the instillation of the tuberculin into the eye."

They conclude that "the ophthalmo-tuberculin reaction is of some value for diagnosis of tuberculosis in cattle. A characteristic conjunctivitis with exudation coming on from six to eight hours, reaching a maximum in from sixteen to twenty-four hours disappearing in forty-eight hours, is noted in tubercular animals. It is important that the pure tuberculin should be used. The ordinary tuberculin which contains peptone, glycerin and carbolic acid should not be used."

The reaction is said to be more pronounced in those animals which have not been recently tested with tuberculin. With this reaction as with the usual tuberculin test one injection and reaction probably inhibit a second reaction during a period of from six weeks to a year. The ordinary tuberculin test does not seem to interfere to any great extent with the ophthalmo-tuberculin test at least within four weeks. The tuberculin test occasionally prevents absolutely a second reaction, and usually no second reaction occurs within six weeks to a year, as before stated. There seems to be a difference in the results on this point.

According to McCampbell and White cattle recently tested with tuberculin by the subcutaneous method react to the ophthalmo-tuberculin test but the reaction is slightly reduced in its intensity. The ophthalmic test may possibly serve as a means of diagnosis of tuberculosis in cattle which have been tested with tuberculin by the ordinary method and will not react a second time, or where tuberculin has been injected into cattle in order that they may clear a second test.

No constitutional disturbance has been noted in any of the cattle tested, that is, no rise in temperature, loss of appetite or falling off in the production of milk. The instillation of tuber-

culin into the eye does not seem to produce the general reaction which attends in some cases the subcutaneous injection of tuberculin. The exudate disappears leaving the eye perfectly normal in about forty-eight hours.

Von Pirquet and Schnürer¹¹ also tested their method on cattle with the following conclusions:

"In accordance with the findings in man and with the statements of Vallée, Guérin, Lignières and Berger for cattle, we can assert that the tuberculous cow, in the same manner as the tuberculous man, reacts to cutaneous and conjunctival introduction of tuberculin with local, characteristic inflammations of the skin and mucous membrane.

"Cattle which show no fever on subcutaneous tuberculin injection also fail to react to cutaneous and conjunctival application of tuberculin.

"On the other hand, tuberculous cattle may show the fever reaction on the injection of the usual large doses, but fail to show the skin and mucous reaction with the present available preparations.

"The positive result of any one of the three tests shows tuberculosis; they are not fundamentally different, but only quantitatively, and in this respect the fever test is to be looked on as the surest, the other two as weaker but about equal in value.

"For the practical method of clearing out tuberculosis from a herd of cattle the simplest process is to employ the conjunctival reaction as a discriminating reaction. In an undoubted positive result the animal is to be regarded as tuberculous; in a doubtful or negative case of the conjunctival test the subcutaneous injection should be applied."

Lignières and Berger¹² modified the method of von Pirquet by rubbing the tuberculin upon the scraped skin rather than into the scarified dermis. They proposed the term *cutis reaction*

¹¹Von Pirquet and Schnürer. Allergie bei Tuberkulose der Rinder. Monatsh. f. prakt. Tierheilkunde, Bd. XIX (1908), S. 405.

¹²Lignières and Berger. Bull. Acad. des Sciences, Paris. 28 Oct., 1907.

for this modification and *dermoreaction* for the method of von Pirquet.

Personally I have tried the eye reaction in a few tuberculous cattle only. In these there was a slight reddening of the conjunctiva in a few cases, but the difference between the injected and non-injected eyes was not sufficient in several cases to warrant a diagnosis. In several animals there did not seem to be any visible effect. The method has the disadvantage, especially in cases of a mild reaction, that the conclusion as to whether there is or is not a reaction depends upon the opinion of the observer in interpreting the appearance of the eyes. This reason is sufficient to cause one to hesitate to recommend it, especially to those who have not given the method careful experimental study. In using it one must take into account the existing conditions which might cause a mild or a temporary conjunctival hyperemia. The statement of von Pirquet and Schnürer that a negative reaction can not be considered conclusive and that it must be followed later with the subcutaneous injection suggests further that it has no advantage over the subcutaneous method.

Intradermal test. Ward and Baker¹³ made a careful test of the intradermal method of injecting tuberculin recommended by Moussu and Mantoux.¹⁴ It consists in injecting tuberculin into the skin. The reaction appears a few hours later as a swelling at the point of injection. Ward and Baker found it to be positive as shown by post mortem in 28 of 30 cases. They recommend it for range cattle.

This method has been tried by many workers both in this country and in Europe. Zschokki found it accurate in about 85 per cent. Luckey and others in this country consider it equal to or better than the subcutaneous method, but we have not found it to be so reliable. It requires a specially prepared tuberculin.

¹³Ward and Baker. Proceedings Am. Vet. Med. Asso., 1910, p. 291.

¹⁴Moussu and Mantoux. Transactions of the Sixth International Congress on Tuberculosis, Vol. IV, part 2, p. 821.

CHAPTER IX

PHYSICAL EXAMINATION IN DETECTING TUBERCULOSIS IN CATTLE

The value of the physical examination of cattle is variously estimated by veterinarians. In this country many of the practitioners do not consider it of much assistance while in Holland and Germany for instance it is believed to be quite sufficient to pick out the dangerously tuberculous animals.

If the nature of the diseased areas and their distribution within the body are kept in mind, it will be clear that a physical examination of the living animal is not likely to detect the presence of the disease in a very large percentage of cases. In proportion to the number of infected cattle there are few in which the disease can be detected by physical signs or symptoms. The usual evidence of its presence are enlarged subcutaneous lymph glands, changes in the udder and general poor appearance where the lungs or abdominal organs are considerably involved. Skill in palpation, percussion and auscultation will often enable one to locate the diseased area. Those animals which are infected and in which the diseased foci are still very small compose by far the larger number of tuberculous cattle.

Since tuberculin has come into use as a diagnostic agent there has been a feeling on the part of many that it was not necessary to develop efficiency or skill in physical examination. This was doubtless due to the fact that such a large number of tuberculous cattle can not be detected on a physical examination that it did not seem wise to apply it to any except perhaps the obviously infected. An inquiry into this phase of diagnosis will show that in the German schools great stress is laid upon the importance of physical examination. We have been told by certain distinguished European veterinarians that "Americans do not know how to make physical examinations". However true the charge may have been in

the past, it is certain that our teachers of veterinary medicine are giving this subject much more attention than formerly. As a result, it is possible for practitioners who have made a study of this subject to detect abnormal conditions in a considerable percentage of infected cattle that give the general appearance of being perfectly healthy. It is not possible for them to say that the enlarged glands, the unnatural respiratory sounds or dullness on percussion are due to tuberculosis. The fact that something is wrong is sufficient to cause the animal to be separated from the other animals in the herd. The positive diagnosis of tuberculosis can be made only after the application of definite methods of procedure such as a bacteriological examination or the application of tuberculin. The physical examination is not to take the place of tuberculin or other definite methods in making a clinical examination.*

Although much importance is attached to the physical examination, the fact must be made clear that it will detect but a small (3 to 5) percentage of infected cattle. This small percentage, however, is for both the owner of the herd and the consumers of the milk of the greatest importance, for it includes most if not all of the infected animals *that are giving off tubercle bacteria*. If a herd is examined carefully at short intervals, it will be possible, in most cases at least, to detect the animals that are developing tuberculosis before the lesions have become advanced sufficiently to allow the germs to escape from the body. This makes the physical examination of value so far as protecting the consumers of the milk and the other animals in the herd, but it does not afford any protection to the purchaser of cattle, *for the occult cases can not be detected by this method*. The value of the method is to protect the herd from its own infection and to allow a sound one to be grown up, but it *does not protect* the purchaser of cattle against buying infected animals.

*A clinical examination includes the use of tuberculin and bacteriological examinations necessary to make a diagnosis. A physical examination locates the affected part.

The objection is raised that it requires much time of a skilled practitioner to make the examinations. This is true to a certain extent, but we should remember that we can not rise above natural laws but must work through them. We can not hasten or retard to an appreciable extent tuberculous processes. When they arrive to a certain condition the skilled diagnostician can detect them and not before. The physical examination of a herd to remove tuberculosis can be likened to the care of a garden. If all the weeds in sight are removed and as fast as the new ones appear they too are removed before they produce seed, until there are no more unsprouted seed or living roots left, there will be no more weeds in the garden, provided of course that no seeds are allowed to come in from without. The physical examination of cattle, if properly made, will in a like manner weed out the infected animals as fast as the disease comes in evidence, and before it has advanced sufficiently to enable its seed to spread. If this can be done the disease must disappear from the herd with the natural elimination of all the present infected cattle.

In Germany and Holland the examination includes the search for tubercle bacteria in the excreta, uterine discharges and milk as well as the evidence of disease from a physical examination.

More recently Director E. Scharr and Dr. Opalka of the Bacteriological Institute of the Agricultural Department for the province of Brandenburg made a report on the bacteriological and physical examination of tuberculosis in cattle¹. They emphasize the importance of the examination of the mucus in the lower part of the trachea and upper bronchi. By means of a trocar, a cotton swab is introduced into the lower part of the trachea and the contents collected on the swab which is examined bacteriologically for tubercle bacteria. The success of this method in finding open cases of

¹This report was translated by A. T. Peters and published as Bulletin No. 5, State Board of Livestock Commissioners of Illinois, 1912.

pulmonary tuberculosis can be determined from their conclusions which are quoted.

"With the aid of our trocar and swab we are enabled to procure safely and easily sputum specimens without injury to the animal.

"To obtain the most positive diagnosis the swab should be inoculated into guinea pigs.

"From our experiments we conclude that open tuberculosis of the lungs can be detected in almost all advanced cases by this method and in a few cases we were able to detect it in the earliest stages where no clinical symptoms (such as cough, emaciation, etc.) were present.

"Serous tuberculosis can not be positively ascertained by this method.

"The described method is a valuable one for the detection of open tuberculosis in cattle. Though it would seem rational to destroy all tuberculous cattle, this can not be done owing to the fact that the percentage of slightly affected animals is too great and the value so enormous that the State can not afford to pay for them all. It is necessary for the sanitary officers to find a more economical method."

This method is being tried in this country but the results are not yet reported. It is restricted naturally to the detection of open pulmonary cases only.

CHAPTER X

IMMUNIZATION OF CATTLE AGAINST TUBERCULOSIS

Experiments directed toward the immunization of animals against tuberculosis have been in progress since the discovery of tuberculin in 1890. The product resulting from the growth of the tubercle bacterium in the body was reported by Koch to have the effect of immunizing experimental animals, of retarding the progress of tuberculosis, and, in some cases, it was thought to cure laboratory animals artificially infected. Koch observed that when a healthy guinea pig is inoculated subcutaneously with a pure culture of tubercle bacteria the lips of the inoculation wound at first unite and adhere and the wound appears to heal. After from ten to fourteen days a hard nodule forms, which breaks and continues as an open ulcer until the death of the animal. But the condition is quite different when an already tuberculous guinea pig is inoculated. In such an animal the wound unites at first, as before, but no nodule forms, and on the second or third day the seat of inoculation sloughs off, leaving a flat, shallow ulceration which usually heals rapidly and permanently. Koch also found that dead tubercle bacteria rubbed up in water could be injected in large quantities into healthy guinea pigs without injury other than suppuration at the point of injection, and that small quantities administered to infected guinea pigs had the effect of prolonging the life of the animals so treated. It, therefore, appeared to be probable that tubercle bacteria contain some specific soluble substances capable of exerting a curative action. It was in an effort to discover this substance that tuberculin was made.

Spengler¹ reported that he had found tuberculin to be capable of prolonging the life of infected guinea pigs and to have a decided curative effect.

¹Spengler. Memoir de la Congrès de la Tuberc. à Paris, 1898.

Koch² came to the conclusion that it was necessary, in the treatment of tuberculosis, to produce not only an immunity to toxins, but also a bacterial immunity, and felt that he had seen evidence of an immunity of a degree sufficient to be of much value. He had observed, in acute miliary tuberculosis, when the bacteria are distributed throughout the entire body, a stage during which the organisms, formerly so numerous, disappear to such an extent that they can be found only with difficulty. It appeared, therefore, that even in these cases there was a sort of bacterial immunity.

Antitoxins found in the blood of animals that have been treated with various toxins or tuberculins have been used to a large extent experimentally for the purpose of immunizing animals against, and treating animals infected with, tuberculosis. Maragliano³ was one of the first workers in this field. He obtained what he believed to be a curative serum by injecting toxins produced by or extracted from tubercle bacteria into experimental animals—i. e., dogs, asses, and horses. Living tubercle bacteria were not administered to the animals that were to produce the serum. It was shown that a serum produced in this way had the ability to neutralize the toxic effect of tuberculin. In 1899 Maragliano reported, at the Tuberculosis Congress in Berlin, that by means of his serum he was able to immunize rabbits and guinea pigs against ordinarily fatal doses of tubercle culture. He announced that his tuberculosis antitoxic serum was produced through methodical and progressive injections of tuberculosis toxin.

Burnheim, Nieman, McFarland, Patterson and deSchweinitz all experimented with normal serums and those procured from animals treated with tubercle bacteria extracts, or tuberculins, but with no practical success.

Von Behring, working in the same field, found that by the use of tuberculin toxins a specific antitoxin could be produced through the use of which the resistance of an animal to tuber-

²Koch. Deut. med. Woch., No. 14, 1897.

³Maragliano. Berlin. klin. Wochenschrift, No. 32, 1895.

culosis could be increased to a certain, but not to a large extent.

The work done by all these investigators may be summed up by saying that it is well established that by the use of a tuberculosis toxin it is possible to immunize an animal against this toxin and to produce resistance to tuberculosis already existing, or to which an animal may subsequently be exposed. But the immunizing or curative results produced by toxins or by antitoxins resulting from the use of toxins, while sufficient to be definite and measurable, have not been proved to be sufficient to be of much practical value so far as the protection of healthy animals against tuberculosis is concerned. Evidently, the effect of their use is to tend to the production of a toxic but not a bacterial immunity.

In 1894, de Schweinitz reported some experiments made by him on guinea pigs, in which these animals were inoculated with tubercle bacteria of human origin, cultivated about twenty generations upon glycerin beef broth of slightly acid reaction. This culture was not virulent for guinea pigs but it served to immunize them to such an extent that when they were afterward inoculated with tuberculous material from a cow, they remained healthy, while control animals inoculated with similar material died with tuberculosis in seven weeks. DeSchweinitz also injected very large quantities of human tubercle bacteria into cattle—subcutaneously, intravenously, and intraperitoneally. He found that by gradually increasing the dose enormous quantities could be tolerated without injury.

M'Fadyean⁴ reported his experiments in the problem of injecting emulsions of tuberculous material and cultures from various sources. His conclusions are quite significant.

"It, therefore, appears to be justifiable to conclude that, whatever may have been the degree of natural immunity possessed by these three experimental cattle, it was much increased by the successive intravenous inoculations to which they were subjected. The immunity was not absolute, but

⁴M'Fadyean. Jour. Comp. Path. and Therap., Vol. XIV (1901) p. 136.

it may be doubted whether a degree of resistance that will merit this term is obtainable by any method in cattle."

The most persistent efforts to immunize cattle have been put forth by von Behring. He has made several reports upon the subject. He has endeavored to immunize animals against tuberculosis by the use of tuberculin, other tuberculosis toxins, by antitoxins, by the use of dead tubercle bacteria, tubercle bacteria weakened by chemical agents, and by the use of living cultures of low virulence (bovolaccine). Cattle treated by him have been tested as to their resistance to tuberculosis by subcutaneous and intravenous inoculations with tuberculous material from cattle and with cultures of virulent tubercle bacteria of the bovine type. The results have not been satisfactory. The experiments by Haring in California and others have shown that little dependence can be placed upon the use of bovolaccine as a practical measure of preventing the disease.

Pearson and Gilliland⁸ experimented along the lines of inoculating cattle with living bacteria. Their conclusions were encouraging. They state: "After repeated intravenous injections of cultures of tubercle bacteria from human sputum the resistance of young cattle to virulent tubercle organisms of bovine origin may be increased to such an extent that they are not injured by inoculation with quantities of such cultures that are capable of causing death or extensive infection of cattle not similarly protected.

"That intravenous injections of much larger quantities of culture of human sputum tubercle bacteria than are necessary to confer a high degree of resistance, or immunity, upon the vaccinated animals, may be administered without danger to that animal."

In a personal conversation with Dr. Pearson shortly before his death, he assured me that while it was possible to increase the resistance of cattle against tuberculosis by repeated intravenous inoculations, a practical method had not yet been devised.

⁸Pearson and Gilliland. Philad. Med. Jour., Nov. 29, 1902.

Thomassen, Neufeld, Weber and Tante, Friedman, Lorenz, Hutyra, Albrecht, Smith, Mohler and Schroeder carried out investigations directed toward immunizing cattle. They all find it possible to establish more or less resistance to the disease.

Haring, Sawyer and Morgan⁶ made a careful test with von Behring's bovovaccine. Their results showed possibly a temporary resistance but not a permanent immunity.

Following the earlier investigations with tuberculin, serums and vaccines there have been a number of experiments reported that are worthy of consideration. The papers on this subject presented at the Ninth International Congress of Veterinary Medicine held at the Hague in 1909 represent the latest and undoubtedly most trustworthy information on this subject.

Eber, of Leipsic, who has studied this subject very thoroughly, concludes as follows concerning preventive inoculations:

"The receptivity of young cattle to experimental infection by virulent tubercle bacteria may be materially diminished by previous inoculation with the Koch bacillus, even of varied origin and virulence.

"The immunity thus conferred is not absolute. The immunized cattle will succumb from the effects of a sufficiently heavy dose of tuberculous virus.

"The increase of resistance is not complete for some time (at least three months) after inoculation, and has entirely disappeared at the end of the first or second year.

"The degree and duration of the experimental immunity are influenced by the individual resistance, and up to a certain point by the quality of the vaccine used.

"No experimental method permits one to foresee the manner in which the vaccinated animals will comport themselves toward natural or enzoötic contagion. Practice alone must decide the value of immunization in the struggle against bovine tuberculosis. Tuberculin does not positively disclose the

⁶Haring, Sawyer and Morgan. Proceedings Am. Vet. Med. Asso., 1909, p. 252.

existence of tuberculous centers upon animals previously treated by injections of living tubercle bacteria.

"Science has not yet granted us a method of inoculation which permits effective struggle against tuberculosis in regions seriously infected."

The newer researches simply shed a little light upon preventive inoculation when combined with other prophylactic measures (killing animals affected with open tuberculosis, raising the calves on sterilized milk, plowing pastures) during the struggle against tuberculosis.

In practice methods of immunization are to be preferred which permit of annual re-inoculations. Nevertheless, more exact researches must be instituted for the purpose of determining if annual preventive inoculations are sufficient in every case to confer satisfactory immunity.

It is of great importance for the future to study further the influence of the mode of inoculation (intravenous, subcutaneous, digestive) upon the quality and duration of the immunity acquired, keeping constantly in mind at the same time the various channels of entrance of natural infection (digestive or respiratory).

Klimmer of Dresden, who had investigated the bovo-vaccine of von Behring, the vaccination with "Tauruman" of Koch and Schütz, the method of Heymanns and one devised by himself, concludes that the methods of von Behring and of Koch and Schütz are practically of no value in combating this disease. His own method, which consists in vaccinating with attenuated human tubercle bacteria, has not been sufficiently tested. The non-tuberculous animals are vaccinated twice during the first year and those that are tuberculous are vaccinated every three months. The following year all the animals are vaccinated but once. It is believed that this method will not be more effective than the others.

Vallée of the Alfort Veterinary College, who has carefully studied the various methods proposed for vaccinating cattle, makes the following statements:

"Nevertheless, the inoculation of cattle by any method with virulent human tubercle bacteria confers an appreciable resistance against various methods of experimental infection and also against natural contagion.

"The resistance conferred is directly proportional to the quantity and virulence of the bacteria injected, but however great their value, the immunity conferred by them does not persist longer than 12 to 18 months.

"The introduction of living bacteria as a vaccine contaminates the entire organism. This peculiarity necessitates a special guard over the animals immunized, should they be sent to slaughter during the six months which follow the last vaccination.

"Whatever the mode chosen for introducing the vaccine, the resistance conferred is insufficient to assure the complete resorption of the bacteria inoculated for prolonging immunity.

"The resistance to infection by the digestive tube of the animal vaccinated by that method is incomparably superior to that acquired by animals by the intravenous method, because it permits the organism to obtain complete resorption of the virulent material inoculated. Considering the frequency of infection through the digestive canal in cattle, the application of vaccinating material through the mouth appears preferable to every other method.

"Vaccination by the digestive method can not be made entirely free from danger of infection if one uses virulent bacilli of the bovine type. The use of bacilli of the human type of slight virulence is, therefore, preferable, as these furnish results comparatively equal to those of the bovine type.

"Vaccination by way of the mouth is not easily obtained except upon very young subjects.

"Vaccination by way of the mouth does not place the animals entirely beyond the danger of infection with tuberculosis. It permits them to resist for more than a year contact with cattle which present open lesions of tuberculosis and following this, present no lesions beyond insignificant tubercular nodules

in the various glands. On this account it merits systematic study and further practical application.

"The resistance conferred by subcutaneous methods is inferior to that obtained by way of the circulation.

"Vaccination by the use of killed bacteria has given results inferior to those obtained with living and virulent organisms.

"No definite conclusion can yet be actually formulated in regard to the various methods of immunization under discussion, but their systematic application will permit a determination of their real practical value."

As a result of the various papers and discussions at the Ninth International Veterinary Congress in 1909 the following resolutions were adopted by that body:

"At the present time there is no vaccination which in itself is sufficient to combat in an efficient manner bovine tuberculosis in heavily infected herds.

"In how far it is possible to bring about a more successful issue of the difficult struggle against bovine tuberculosis by a combination of vaccination with prophylactic and hygienic measures must be demonstrated by new practical experiments.

"The congress urgently requests the Governments to grant the means for extensive experiments to examine the methods of vaccination against bovine tuberculosis under the different conditions of agricultural practice."

The Bureau of Animal Industry, U. S. Department of Agriculture, has carried out a number of experiments directed toward a practical method of immunizing cattle against tuberculosis. The conclusion* reached is as follows: "The only conclusion to which we are entitled from this work and from careful study of the writings of others on the subject of protective inoculation against tuberculosis may be stated as follows: Though results have been obtained which are very encouraging to the investigator and which prompt him to strive onward with renewed vigor and hope, no system of

*Report, B. A. I., 1910, p. 327.

bovo-vaccination has reached a stage at the present time that justifies its use in common practice."

It is impossible in a work of this kind to enter into a discussion of the theories of immunity but the fact that individuals who have suffered an attack of tuberculosis and have recovered at least temporarily are not protected against a subsequent attack or recurrence does not argue in favor of a protective vaccination. Success may be attained but at present there seems to be no method that can be recommended to the cattle owner for successfully vaccinating or immunizing his animals against tuberculosis.

CHAPTER XI

THE CONTROL OF BOVINE TUBERCULOSIS

The vital question for the cattle owner is, How can tuberculosis be prevented or eliminated? If I have been clear in pointing out the nature of tuberculosis, it is evident that the question of control must be solved the same as other problems of a biological nature. As tuberculosis appeared in cattle early in the history of the species, it had a long time to become disseminated through its natural channels of transfer and transportation before it encountered the hostile activities of preventive medicine. Yet the history of the disease shows that in many countries, such as Denmark and Sweden, it did not exist until it was introduced with infected animals in comparatively recent time. More than this, in countries where it now prevails extensively there are many uninfected herds. The efficiency of the natural forces to spread the virus has been heightened during recent years, especially in dairy districts, by the steady increase in cattle traffic. Individual dairymen have bought and sold cattle regardless of this infection, thereby introducing it into thousands of herds where by nature's method of dissemination the virus would not have gained entrance. We are at once confronted, therefore, by the situation in which the natural powers for the dissemination of tubercle bacteria have been and still are being accelerated by the habits of the dairymen. The problem of control is a complicated one, because the spread of the virus through these natural channels must be checked and the habits of the dairymen so adjusted that they will tend to prevent rather than enhance the spread of the specific bacteria. Again, the problem is complicated because the infected animals possess a greater or less intrinsic value. Methods for control should provide not only for checking the further spread of the virus, but also for the utilization so far as possible of the

infected individuals. The subject becomes further subdivided because of its sanitary significance as well as its economic importance.

The economic problem is many sided. In some instances whole herds are infected. These are frequently the only source of revenue for their owners. Large numbers of these cattle are suffering with single or localized foci of the disease, which leave the carcass fit for food. Every year our Government inspectors pass for sound beef thousands of animals so affected. Again, there are many herds of cattle valuable for their pure blood or special strains that have been obtained after years of expensive effort in breeding. These have a value to the dairy industry that is difficult to measure. Many of these herds may be tuberculous. We know that some of them are. Of the infected individuals a very large percentage are but slightly diseased. However, because of this infection they are a menace to the healthy animals, but most of them still possess their essential value, the ability to breed. These can be segregated and their offspring procured free from the taint of tuberculous parasitism with which their dams are suffering. The Bang method, which has been successfully and extensively applied in Europe and in many herds in this country, provides for a safe and economic handling of this class of animals.

The control of a disease like tuberculosis after it has become widely disseminated is difficult because of its insidious nature. The purpose is to detect the infected individuals, but to do this we must recognize the course of the disease in the animal body and the limitations of our means for detecting it. The mere testing of large numbers of cattle with tuberculin requires much time and many men. Its application must be repeated to detect the cases of active disease which are very likely to develop from the latent ones that escape detection on the first test. The men who apply the tuberculin should be trained and competent or the results will be untrustworthy. The use of tuberculin is comparatively recent and generally

not well understood. It is too sensitive a reagent to be trusted to the unskilled. An equitable and just disposal of the reacting animals must be provided for. Owners must cooperate and they must learn the nature of the disease and its disastrous effects upon the herd if allowed to continue unchecked. State and municipal meat inspection services are a necessary complement to afford a ready and legitimate exit for many reacting animals. The whole proposition is complicated. However, the principle of segregation—to prevent the further spread of the virus—is clear, and its application is not necessarily difficult. If the spread of tubercle bacteria could be stopped, and this is possible, tuberculosis would disappear with the present infected individuals. Because of the great values and the large number of animals involved and the necessity of supplying a constantly increasing quantity of milk, new dairy methods are necessary to meet the present conditions. Dairymen should raise more calves and buy fewer milch cows unless they can be assured of sound herds from which to purchase. The herd is the unit to be considered, not the individual animal. These are among the principles that must be worked out by those wishing to eradicate tuberculosis.

The dairymen are looking to the professional men, the Experiment Stations, and State Colleges for a remedy. The procedure recommended must, if successful, take into account nature's methods for maintaining and disseminating tubercle bacteria. If nature's methods here are objectionable or destructive to man's best interests, as they are in reference to many other conditions, then it is for the scientific investigator to ascertain how these natural forces may be directed so as not to infringe upon man's rights, or so that the agencies through which they operate are eliminated. The analysis of the problem shows that we must deal (1) with what tubercle bacteria through their natural channels can and will accomplish if undisturbed, and (2) what cattle owners are doing to enhance the normal means for their distribution.

In this warfare the responsibility of the individual cattle

owners must not be overlooked. The obligation owed to the producers by the consumers, who are clamoring for pure milk, must likewise be recognized. While those charged with the responsibility of controlling infectious diseases are educating the farmer that he can not afford to have tuberculosis in his cattle and teaching him how to free his herd of this parasitism, they should instruct the consumers that a pure milk can not be produced at the same price that a dirty milk can be sold for.

As the prevention of bovine tuberculosis rests almost entirely with the cattle owners themselves, who will be successful according to the extent to which they adhere to the knowledge of the disease itself, and as this knowledge has been and is being given to them in bulletins, agricultural papers, and lectures, the question of how long the state is going to compensate owners for tuberculous cattle as an aid to its elimination is an important one. There is developing a feeling that the state should not compensate owners for tuberculous animals. In New York the compensation for such animals has recently been increased, but the question whether such a law is right is being discussed in many quarters. The question, why a man should be paid for a tuberculous animal any more than for one dead of anthrax or any other preventable disease, is being asked repeatedly. In some states there is small compensation, and in others its discontinuance is being urged. The tendency seems to be that payment for such cattle from public funds is to be temporary.

There have been several well-defined methods established in different countries for controlling tuberculosis in cattle. These may be mentioned by countries.

America. Active measures to suppress tuberculosis in cattle were first undertaken in the United States and Canada. The American system of control consists in tuberculin testing dairy cattle and slaughtering the reactors. It was the first procedure inaugurated to eradicate the disease. It was started when the authorities believed that human and bovine tubercle bacteria were identical and when tuberculin was

thought to give a reaction in all infected animals. It started as an official measure and carried indemnity from the state for the infected animals. Such payment was justified on the ground of public safety and equity to the owners. With slight modifications the system has continued in operation since its introduction. Could this method have been introduced soon after the infection occurred, it would have been successful generally as it has been in certain localities and in single herds where all tuberculous cattle seem to have been identified and eliminated. By this a large number of herds have been purified and their owners enabled to keep thereafter uninfected cattle. Unfortunately in point of time this method came so late that in many states there were so many infected animals that necessary funds could not be secured to test all herds and to indemnify the owners of all reacting cattle. Again the disease had existed for so long that there was such a large number of arrested cases that a single test would not detect all of the infected individuals.

The official use of tuberculin has been and still is restricted to a small percentage of the cattle. In New York it is less than two per cent annually. Local boards of health and milk commissions have required testing of perhaps 5 to 10 per cent more. But even this is not sufficient to insure any great decrease in the number of tuberculous cattle. A very large part of the remaining ninety per cent are not tested. In these tuberculosis is continuing to spread according to its own methods. There is more or less private testing, but where the laws are too stringent dairymen themselves are not active in finding the disease. The health authorities and often consumers will not permit the reacting cows to remain in the milking herd, although evidence of disease cannot be detected except with tuberculin. At the same time milk is accepted from herds that have never been tested and which often contain spreaders of the virus, as shown by an examination of the milk.

A long and careful study of tuberculin has shown, as

already stated, that with a reaction there is present an active tuberculous infection but its failure to react does not prove the absence of the disease.* Experience has shown and theory explained that when infection exists either in the period of incubation or in a state of arrest tuberculin is not effective. These findings have answered many of the criticisms that have been raised against tuberculin. These are usually made by those lacking knowledge of when it can and when it cannot cause a reaction. Many of these important facts have been disregarded, and the system, while applied with good faith, has occasionally allowed infection to remain in some animals in the herd. In these, the disease has sooner or later developed, and the herd has again become a center for dissemination. For this tuberculin has been unjustly blamed and not infrequently the integrity of the men who used it has been called in question. Unfortunately in this country the use of tuberculin has come all too often to be considered synonymous with the slaughter of a herd and not as an agent of the greatest value in diagnosis.

The supposition that all reacting animals are immediately dangerous has been carefully investigated. Many examinations of milk, feces and saliva of infected cattle have been made to ascertain the extent to which open cases of tuberculosis exist without giving physical evidence of the same. This work is now in active progress but the results already reported** indicate that spreaders of the virus can be detected in a very large percentage of cases on physical examination.

*See Resolution 2, on tuberculin, passed by the International Commission on the Control of Bovine Tuberculosis, in Appendix.

**Moore and Boynton. N. Y. State Dept. Health, 29th Annual Report, 1908.

Moore. Report of the N. Y. State Veterinary College at Cornell University, 1910, p. 46.

The Elimination of Tubercle Bacteria from Infected Cattle. The Jour. of Med. Research, Vol. XXIV (1911), p. 517.

Peterson. Report of the N. Y. State Veterinary College at Cornell University, 1910, p. 60.

Such men as Prof. Ostertag of the German "Gesundheitsamte" and Dr. Poels, Director of the tuberculosis work in Holland, trace failure to detect "spreaders" of tubercle bacteria to a lack of skill on the part of the examiner. Although our system of testing and destroying the reactors was right from the viewpoint of those who introduced the law, in general its results do not seem to have been so satisfactory or even to have equalled the attainments of the methods based on a broader knowledge of the disease and the means for the dissemination of its virus.

In 1909 the American Veterinary Medical Association appointed a commission to investigate and report upon a method for the control of bovine tuberculosis. (See appendix for its report and recommendations.) This report, which consists of a series of resolutions and a general plan of procedure for cattle owners, seems to meet the situation as it exists in this country. For this reason the report is reprinted as an appendix to this work. The plan there recommended seems to cover every possible condition.

Denmark. In Denmark the method known as the "Bang method," in honor of Professor Bang who introduced it in 1894, is the direct and official procedure followed. It consists in the government testing with tuberculin all the cattle in a herd when requested to do so by the owner, who agrees to comply with the government requirements. These consist in separating the reacting animals from the non-reacting ones, either by placing them in different stables or by putting up a partition in the same stable. When outside they are kept in separate paddocks or fields. The advanced cases and all the

Reynolds and Beebe. Dissemination of Tuberculosis by the Manure of Infected Cattle. Bulletin No. 103, Agric. Exp. Sta., Univ. of Minnesota, 1907.

Reichel and Deubler. An Examination of the Feces of Forty Cattle for Tubercl Bacilli and Conclusions. Jour. of Med. Research, Vol. XXIV (1911) p. 5.

Schröder. The Unsuspected but Dangerously Tuberculous Cow. Circular 118, U. S. Bureau of Animal Industry, 1907.

cows with udder tuberculosis are eliminated. The non-reacting animals are tested every six months or a year, and if any of them give a reaction they are placed with the reactors. The calves of the infected cows are removed promptly after their birth from their dams and fed the milk of the sound nurse cows or the pasteurized milk of the infected ones. As soon as the sound herd is of sufficient size, the reacting animals are eliminated and their stable thoroughly disinfected. As a precaution all of the separated milk at creameries is pasteurized at 80° C. before it is returned to the farm.

The success of the Bang method in Denmark where it has been most extensively employed has been made possible because of two important conditions, viz: (1) The farmer is allowed to sell the milk of the reacting cows with that of the healthy ones, except where the local authorities object or where infants' or children's milk is produced. (2) The owners are allowed to sell the reacting animals to whom and where they please. This freedom of action enables cattle owners to eliminate undesirable animals and to keep for breeding purposes the better ones. As the milk is used and the cattle can be sold, the method is carried out with little loss to the owner, with small cost to the state and at the same time it protects the consumers of the milk.

On the question of eliminating tuberculosis, Professor Bang states that by removing all of the udder and other clinical cases, the danger from the milk is minimized and, therefore, it is much safer than it was before the herd was tested. The sale of reacting cattle is not prohibited, because it would prevent farmers from eliminating the infected individuals from their herds. So long as a large percentage of the herds are infected, the Danish government sees no objection to this practice. In conversation with Prof. Bang on this subject, he stated that in a country where tuberculosis is prevalent "It is no worse to sell a cow that reacts to tuberculin than it is to sell one that has not been tested." He would not approve of this practice if most of the herds were free

or if the government assumed control of *all* herds and compensated the farmers for the reacting animals.

The Bang method, modified to suit the local conditions, has been applied with great success in Hungary, where the reports show that many highly infected herds have been freed of the disease in from four to six years. In Norway and Sweden the results have been equally good. Prof. Regner¹ states that the percentage of reacting animals among 36,149 cattle was, at the beginning of the application of this method, 33.6 per cent. After a period of from two to nine years, in different herds, it was reduced to 4.7 per cent.

Among the first, if not the first, to put the Bang method to a test in the United States was the Wisconsin Agricultural Experiment Station². They began in January, 1896, with 16 reacting animals and 18 healthy cattle. In February, 1899, they had 27 healthy animals all the progeny of the group of tuberculous cattle. Russell pointed out at the time that the method afforded a practical and often a most desirable way to replace a tuberculous herd.

The method has been successfully applied at the Geneva Experiment Station³. In October, 1901, the test of the herd showed 13 healthy and 17 tuberculous animals. They were separated and the method carried out. The station suffered a loss of four healthy animals in a fire, and only a small number of heifer calves were born; but with all these disadvantages, in December, 1905, the herd numbered 30 sound animals and six tuberculous ones. The latter were slaughtered. Of the six, three would have passed the Federal inspection and their beef value been obtained had they been disposed of in that manner.

¹Regner, Gustav. The suppression of tuberculosis among domesticated animals. Eighth International Veterinary Congress, Budapest, Sept., 1905.

²Russell, H. L. The history of a tuberculous herd of cows. Wis. Agr. Exp. Sta., Bull. 78, 1899.

³Harding, H. A., Smith, Geo. A., and Moore, V. A. The Bang method of controlling tuberculosis, with an illustration of its application. Bulletin No. 277, N. Y. Agr. Exp. Sta., Geneva, N. Y., 1896.

The same process has been followed by a number of cattle owners with most gratifying results. The Hon. W. E. Edwards, of Rockland, Ontario, Canada, used it in the handling of his valuable herd. In 1903, at the meeting of the American Veterinary Medical Association, he read a most forceful paper⁴ on his experience with the method, a few lines of which I quote: "The question arises, can tuberculosis, one of the most constant diseases present in our animals, be eradicated? My answer is, yes, most emphatically. I am fully convinced of the reasonable possibility of the eradication of tuberculosis from our herds and of the maintenance of sound herds."

The method is being applied most successfully by a number of cattle owners in New York State.

The Danish method requires from three to ten years to build up a sound herd from an infected one. The further and most important lesson to be taught by it is that the owner himself becomes educated in the nature of the disease, so that thereafter he will keep his herd free. Such men will not purchase reacting animals. The dairymen are learning that it is necessary to raise their own cows or to buy them from *sound* herds.

I saw a number of herds both large and small where this method was being or had been carried out. It was quite as effective in the small as in the large herds. The Bang method is generally considered by cattle owners in Denmark to be entirely satisfactory, and if carefully applied to give the desired results. The increased profits accruing to those who have sound herds are tending to bring more and more farmers to apply the method. If a farmer who applies for assistance refuses to comply with the government demands, the request is denied. Certain veterinarians have organized clubs among cattle owners for the purpose of hastening the application of the method to all infected herds.

In Denmark the government gives compensation for cases

⁴Edwards, Hon. W. E. The Bang system for the eradication of tuberculosis in cattle. Proceedings of the Am. Vet. Med. Asso., 1903, p. 124.

of udder tuberculosis only. Professor Bang would like to have compensation given for cases of open tuberculosis of the lungs, intestines and uterus as well as of the udder.

While in this country, as stated above, the Bang method has been frequently applied with perfect success, it is considered by many as impractical.

England. In England there has not been up to the present much direct official effort to control bovine tuberculosis. In many places the milk is more or less regularly examined for tubercle bacteria, and if they are found each of the animals in the herds from which the milk came is carefully examined physically, and the milk of all the cows that are found to be suspicious is examined bacteriologically. If tubercle bacteria are found, the animal is slaughtered at once or, more usually, fattened and killed under inspection for beef. Under the new regulations, tuberculin can be used with the consent of the owner or his agent, but not otherwise.

The procedure which is known as the Manchester method consists in taking milk from the dealers and examining it at regular intervals for tubercle bacteria. Professor Delépine's technique consists, in addition to such microscopic examinations as may be made, of the inoculation of small guinea pigs subcutaneously on the inside of the thigh with the sediment of centrifuged milk and killing them about twenty-one days later for examination. If tuberculosis is found the examination extends to the individual cows in the herd from which the infected milk came. Professor Rubert Boyce of Liverpool stated that by this method they had reduced the infected milk supply in that city to 6 per cent.

There is no restriction on the sale of reacting cows, and ordinarily the milk from the reactors and non-reactors is mixed and sold, except where children's milk is being produced. The Bang method is being applied to some extent by private owners, but generally it does not seem to be favorably considered. There is no country where the feeling is stronger that bovine tuberculosis is of great sanitary signifi-

cance than in Great Britain. There seems to be no other where so little direct effort has been put forth to eliminate this disease from cattle. The general examination of the milk for tubercle bacteria has, however, done much indirectly to lessen the number of clinical cases of tuberculosis in the herds of the country.

Germany. In Germany the method of separating the sound from the reacting animals as followed in Denmark is not looked upon with favor, largely because of the difficulty in separating the two classes. The law did not provide for compensation to the owners of cattle, although an act recently passed provides for the condemnation with compensation for open cases of lung, intestinal, uterine and udder tuberculosis. There are, however, in the different provinces local regulations, and some of these provide for a small compensation in certain cases.

The method which, for some time, has received most attention is that proposed by Dr. Ostertag. It consists in eliminating by slaughter all clinical cases of tuberculosis, removing the calves promptly after their birth from their dams and keeping them separated for some months, after which they may be placed with the other cattle. During this early period the calves are to be fed on the milk of sound cows or on the pasteurized (heated to 85° C.) milk of the infected ones. It is considered somewhat safer to prolong the separation until a sound herd is built up. When cattle owners desire to do so, they have their herds tested with tuberculin, but as a rule they do not separate the reactors from the others. The herds are examined *frequently* by skilled veterinarians and all the animals that exhibit symptoms of tuberculosis are immediately eliminated either by isolation or slaughter. In this way it is believed that the disease will be kept in check and eventually the infected animals will disappear. Ostertag thinks that tuberculosis can be eradicated by promptly removing the clinical cases, with the simultaneous raising of young cattle free from infection. The Ostertag method is based on the

theory that the clinical cases are so largely the spreaders of the virus that the few occult cases which eliminate tubercle bacteria may be considered as a negligible quantity. In this country, the Ostertag method is generally considered to be the treatment of the entire existing herd as a tuberculous one, and the building up of a new and sound herd from the offspring.

Holland. In Holland, by Royal decree the government gives facilities for the official inspection of cattle destined for exportation. Further, by a decree of the Queen, any cattle owner can present animals to be examined by a government inspector if they are accompanied by a certificate from a veterinarian that the animal or animals are suffering from tuberculosis. If the diagnosis is tuberculosis, the animals are slaughtered and if they pass the inspection their carcasses are sold for food. If the government veterinarian is not sure of the diagnosis on physical examination he employs tuberculin. In all cases when the animals presented are found to be tuberculous, all of the cattle in the herd from which they came are inspected. If the veterinarian is in doubt regarding the diagnosis, the animals are tested with tuberculin. If tubercle bacteria are found in the mucus from the lungs or uterus or in the milk, the cow is killed.

At present cattle belonging to breeders only are killed and compensated for by the government.

Professor Poels thinks that tuberculosis of cattle must be combated slowly. He believes that the only way is to kill off the animals suffering with evident tuberculosis. Bang's method is not favored, in fact it was stated that it was impossible. Professor Poels also lays great emphasis upon physical examination as a means of detecting tuberculosis. He emphasizes the importance of greater skill in clinical examination. With Professor Bang he finds many cases of uterine tuberculosis and places much stress upon the bacteriological examination of uterine discharges.

Professor Poels, like Dr. Ostertag, believes that reacting cows in the absence of physical symptoms rarely disseminate

tubercle bacteria. It is not an unusual practice to feed the calves the mixed milk from the reactors and non-reactors, and later test them with tuberculin and slaughter, under inspection, for food all that react. The infection under such conditions is so rare that the loss is of less importance than the extra work of feeding the calves on sound milk or pasteurized milk from infected cows.

The practice in all of the countries mentioned, except the United States, of using the milk, except for infants and children, from tuberculin reacting cows that do not exhibit symptoms, and the freedom in selling such animals, make it possible for dairymen who desire to do so to clean up their herds without great financial loss and at the same time encourage them to do so. The experience in Europe tends very strongly to the issue whether in the government control of tuberculosis cases of infection not recognizable on physical examination should be included in so far as compulsion of action is concerned. In Germany the clinical cases only are reported. The lesson from the experience in Denmark is that in order to keep herds free from tuberculosis the owner must be educated in the nature of the disease and that *until he is thus educated* there is little hope of securing herds permanently free from the disease. The essential lesson of the Bang and Ostertag methods lies in the fact that when a herd is purified the owner has become so thoroughly versed in the nature of the disease that he is able thereafter to keep his animals free from it. Methods for the control of tuberculosis can not be too radical so long as the disease is widespread. Its eradication will be brought about through a process of eliminating the animals that are active in disseminating the virus and those that are developing lesions that in the near future will give off the bacteria. In addition to the exclusion of all animals exhibiting evidence of the disease, all those that are infected, as determined by tuberculin test, should be excluded as soon as sound animals are grown up to replace them.

The method to be followed by any individual who has an

infected herd must be determined by the existing conditions and to a certain extent the wishes of the owner. If the owner is anxious to eradicate the disease quickly the best plan seems to be to test with tuberculin and eliminate the reactors. The testing should be repeated every six months so long as any reactors are found and annually thereafter. The cattle should be given a physical examination frequently in order to detect advancing cases that occasionally appear between the times of applying tuberculin.

If the herd consists of valuable animals the method chosen should tend to the conservation of the animals by following a more conservative procedure. If the herd is extensively infected, or for any other reason an owner can not afford or does not care to exterminate the disease as quickly as it is possible to do so, he can follow the German or Danish method and in a few years have with the going out of the old cattle a young and healthy herd to take its place. In any case, all animals showing evidence of tuberculosis should be promptly removed from the herd. The one point to keep in mind is that tubercle bacteria must not be allowed to escape from any infected individual. This can be prevented by removing from the herd every animal as *soon* as it gives any evidence whatever of being infected. It is important that they are removed before the lesions become open and the bacteria escape.

DISINFECTION

One of the most important factors to be considered in the eradication of tuberculosis is the thorough disinfection of the stable from which open cases of tuberculous cattle have been removed. There is much confusion in the literature on the disinfection for tuberculosis. Various methods have been employed and many germicidal substances or disinfectants have been used.

In disinfecting stables, it is essential, before applying the disinfectant, to remove all litter, which should be burned or thoroughly soaked with the disinfectant, and secondly, the

floors and walls should be thoroughly cleaned to insure its free access. The thorough scrubbing of the manger, gutter and walls with a hot soda solution will increase the efficiency of the disinfectant. All cracks and crevices are to be soaked to the bottom with the disinfectant, if a liquid is used, and if a gas is chosen they should be thoroughly cleaned to enable its free access. In the application of disinfectants it is necessary to understand the disinfecting power of the agent used with reference to tubercle bacteria. Experience has shown that there is apparently considerable variation in the resisting power of these organisms under different conditions.

In the choice of a disinfectant, several factors are to be considered.

First, in regard to the disinfectant itself. It is important to choose an agent that is stable and uniform in its action such for example as acids, alcohols or stable chemicals such as corrosive sublimate. Certain of the compounds of substances in themselves valuable are found sometimes not to be uniform in their action. However, the cresols and certain of their compounds are highly recommended.

Second, the effect upon the substance to be disinfected. Some agents are not satisfactory in the disinfection of substances containing organic matter. Again, chemicals that are in themselves poisonous in small quantities should not be used in the disinfection of mangers unless they are thoroughly cleansed after the disinfection is completed.

Third, facility of use and cost. A further choice of the germicidal agent lies in the facility with which it can be applied and its cost. In the disinfection of stables, one must employ solutions stronger than the minimum strength found to be effective especially on young cultures of the organism.

For the disinfection of stables, the germicides that are used in solution are more satisfactory than the gases such as formaldehyde with steam, because ordinarily it is impossible to tightly seal the space. In applying disinfectants it is necessary

to use either a broom or brush with which the floor, manger, gutter and walls are actually scrubbed with the solution of the disinfectant or to employ a spray which is accomplished by the use of some of the spray pumps now on the market. For the disinfection of yards or fences around paddocks the "cyclone burner" attached to the end of a long iron tube with a wooden shield can be used to burn over the surface. This, however, because of the danger of fire, can not be recommended for general use.

The more commonly used disinfectants are bichloride of mercury, carbolic acid (phenol), sulphur, calcium compounds, formalin and the cresols. Formaldehyde is usually employed in the gaseous form. For stable disinfection this is usually impractical owing to the difficulty of sealing up the windows and cracks. There are, however, many other preparations that are used.

Bichloride of mercury or corrosive sublimate is a very good disinfectant in solution of 1 part to 1000 parts of water. It has, however, the disadvantage of being very poisonous and consequently can not be used without the greatest care. It has the advantage of being very inexpensive and when it can be intelligently applied with a brush or broom and the mangers and walls carefully washed after the disinfecting solution has dried, it can be used. Carbolic acid or phenol in 5% solution is also very destructive to tubercle bacteria. This may be applied by means of a broom or brush or with a spray pump. It has the disadvantage of being somewhat expensive.

Liquid formaldehyde, that is, 5% solution of formalin in water, can be applied directly. It is a very efficient disinfectant, being considered better than a 5% solution of carbolic acid, and it is much cheaper. It has the disadvantage of being very irritating to the mucous membrane of the eyes and nose and is therefore disagreeable to use. It is frequently applied with a spray.

In Farmers' Bulletin No. 345, issued by the U. S. Depart-

ment of Agriculture, on Some Common Disinfectants, Dr. Dorset has recommended in addition to the disinfectants mentioned, crude carbolic acid, cresol, a compound solution of cresol known in the U. S. Pharmacopoeia as *liquor cresolis compositus* and chlorinated lime.

One of the disinfectants early recommended for stable disinfection was a solution of equal parts (one-half gallon) of crude sulphuric acid and crude carbolic acid.

These two substances should be mixed in wooden tubs or glass vessels. The sulphuric acid is very slowly added to the carbolic acid. During the mixing a large amount of heat is developed. The disinfecting power is heightened if the amount of heat is kept down by placing the tub or demijohn containing the carbolic acid in cold water, while the sulphuric acid is being added. The resulting mixture is added to water in the ratio of 1 to 20. One gallon of mixed acid will thus furnish 20 gallons of a strong disinfecting solution having a slightly milky appearance. The mixture should be applied to the walls and floors of the stables, saturating them with it.

McClintic⁶ gives a list of a considerable number of disinfectants, largely manufactured products, which have been tested and compared with carbolic acid. The following are included in that list. They are all reported to be somewhat stronger than carbolic acid. Carbolene, which is used 1 part to 100 parts of water. Chloro-naphtholeum, which is used in from 1 to 2 parts in 100 parts of water. Creolin-Pearson is used in from 2 to 3 parts in 100 of water. Creso is used in solutions of from 2 to 3 parts to 100 of water. Lysol should be used in a strength of from 2 to 3 parts to 100 parts of water. Chlorinated lime used in solution of 5 oz. chlorinated lime to a gallon of water is very effective, but it possesses the disadvantage of leaving a strong chlorine odor. Milk of lime and even lime water possess considerable disinfecting power.

⁶McClintic. Bulletin No. 82, Public Health and Marine Hospital Service, Washington, 1912.

In disinfecting stables, it is well to use germicides that do not possess too much of an odor that may be absorbed by the milk thereby modifying its flavor.

It should be remembered that drying and direct sunlight are both destructive to tubercle bacteria. They will, however, live for a considerable time on dry mangers. This is especially true when they are protected by a thin coat of mucus as is usually the case when they come from the mouth.

If the stables are much dilapidated, it is exceedingly difficult to thoroughly disinfect them. In such cases it is generally cheaper to put in new floors and mangers. Wherever open cases of tuberculosis have been housed, thorough disinfection is important.

NECESSITY OF A STATE MEAT INSPECTION SERVICE IN CONNECTION WITH THE CONTROL OF TUBERCULOSIS

One of the advantages in the control of tuberculosis over most if not all other infectious diseases is that the flesh of the infected animals is suitable for human food if the disease is still localized. This makes it possible for the carcass of a cow reacting to tuberculin or one which has an enlarged gland or a slight cough and which is in good flesh to still retain its beef value. When the examination reveals an enlarged gland, an area of dullness in a lung or any other indication suspicious of tuberculosis the owner can, if there is a proper inspection, have the animal slaughtered for beef and if she passes, recover her meat value. In many instances with grade herds this is a good percentage of what she is worth as a milk producer. At present if the salvage is to be saved the infected cattle have to be shipped to some abattoir having Federal inspection or they are killed without official examination. In the first instance the expense prohibits in most cases the securing of such inspection and in the second place, little protection is guaranteed to the consumer of the flesh if it is inspected by the butcher only. If there were a systematic meat inspection service, cattle owners

could, with perfect safety to the public, dispose of all suspicious cases for beef. The practice that has been in vogue of slaughtering reacting animals and not utilizing their flesh when fit for food has been an unnecessary if not unwarranted waste. The large number of tuberculous animals found by our federal inspectors and the considerable number of infected cattle that are, because of the localized condition of the lesions, passed for food point to the economic importance of having a similar protection for those who kill home grown animals. Unless some equitable provision is made whereby owners of reacting and suspicious cattle can utilize them so far as it is safe to do so, just so much more difficult will it be to eradicate tuberculosis from cattle.

Tuberculosis has gradually grown into many herds of dairy cattle. It should be guided in such a way that it will grow out. The secret of accomplishing this is to prevent the spread of tubercle bacteria from the present infected cattle so that with the disappearance of the animals now infected this destructive disease will be no more. It is well to keep in mind the words of the great Pasteur, "It is within the power of man to eliminate the infectious diseases from the face of the earth".

APPENDIX

REPORT OF THE INTERNATIONAL COMMISSION ON THE CONTROL OF BOVINE TUBERCULOSIS*

To the President of the American Veterinary Medical Association:

Owing to the great economic and sanitary significance of animal tuberculosis to the live stock industry of America, and the many and varied factors which must of necessity be accounted with in formulating successful measures for its eradication, the American Veterinary Medical Association, at its meeting in Chicago in September, 1909, appointed the International Commission on the Control of Bovine Tuberculosis. The Commission was instructed to study the problem of tuberculosis among cattle and to report at the next meeting of the Association upon reasonable and economically practicable methods or systems to be recommended to both officials and live stock owners for eradicating this great scourge of domesticated animals.

It is recognized that tuberculosis is widely prevalent among cattle and other animals and that the frequency with which this great evil occurs is increasing rather than declining. As tuberculosis is one of the strictly preventable infections, there is good ground for the belief that through the formulation and enforcement of proper regulations the disease may eventually be entirely suppressed.

*The Members were: Dr. J. G. Rutherford, Ottawa, Canada, Chairman; Dr. M. H. Reynolds, St. Paul, Minn., Secretary; Senator W. C. Edwards, Ottawa, Canada; Mr. J. J. Ferguson, Chicago, Ill.; Mr. J. W. Flavelle, Toronto, Can.; Hon. W. D. Hoard, Fort Atkinson, Wis.; Dr. C. A. Hodgetts, Toronto, Can.; Dr. J. N. Hurty, Indianapolis, Ind.; Dr. J. R. Mohler, Washington, D. C.; Dr. V. A. Moore, Ithaca, N. Y.; Dr. M. P. Ravenel, Madison, Wis.; Dr. E. C. Schroeder, Washington, D. C.; Mr. T. W. Tomlinson, Denver, Col.; Dr. F. Torrance, Winnipeg, Can.

The Commission has held four meetings as follows:— Buffalo, New York, December 13 and 14, 1909; Detroit, Michigan, March 1 and 2, 1910; Ottawa, Canada, May 19, 20 and 21, 1910; Madison, Wisconsin, June 27 and 28, 1910; all of which were well attended, very few of the members having on any occasion been absent. The Commission begs to present as a result of its labors the following report which, although brief, will, on examination, be found to comprise the principal points essential to the promulgation of a comprehensive and practical policy, such as may reasonably be adopted by any governmental body interested in the control of bovine tuberculosis.

It is quite unnecessary in view of the extensive knowledge already possessed by all who are familiar with the efforts which have hitherto been made to secure control of bovine tuberculosis, to dwell at any length upon the importance of the subject or upon the conditions which led to the formation of the Commission.

In view of the personnel of the Commission as selected by the American Veterinary Medical Association, and of the fact that so much information on the subject has been made available through the work of similar bodies in other countries, and the researches of scientific and practical men in America and elsewhere, the Commission has not deemed it necessary to take any evidence either from expert witnesses or others.

The members fully understood that the purpose which their appointment was intended to serve was less the acquisition of new knowledge regarding bovine tuberculosis, than the careful study of the knowledge already available, and of the thoughts and opinions of those most entitled to speak with authority on the subject.

The conclusions reached in this report are, therefore, simply the outcome of an earnest and thoughtful consideration of the various modern aspects and phases of the problem, with the object of crystallizing public opinion and so clearing the way for legislative action.

They realized also that they could deal with fundamental principles only, and that the details of any policy which they might outline, must in each case, be worked out by the duly authorized and responsible representatives of the community immediately concerned.

They nevertheless deemed it essential to study closely the history of the various efforts hitherto made by such countries throughout the world as have attempted to legislate on the subject.

This naturally led to the gradual elimination of all methods other than such as might reasonably be adopted by any community desiring, in the full light of present day knowledge, to undertake the control of bovine tuberculosis.

It was felt, in view of the prevalence of the disease, especially in some localities and among certain classes of cattle, the difficulty of providing a sufficient number of trained officials and the large economic questions involved, to say nothing of the enormous expenditure, that it would be unwise for the present at least, to seriously discuss a policy of universal compulsory testing and slaughter.

Such a policy might perhaps be adopted with advantage by a small community, or one in which the disease existed to a very limited extent, but speaking generally, especially in view of past experiences in this line, it was thought better to omit it entirely from the recommendations of the Commission.

All other methods of dealing with bovine tuberculosis which have been recommended or tried in various communities, were thoroughly discussed, with the object of discarding weak points and adopting such features as might be deemed worthy of a place in the official findings of the Commission.

Every phase of the subject was in this way fully and freely considered, it being thought best to cover the whole ground as completely as possible before coming to a definite decision on any one point.

In order to still further minimize the risk of omitting from the deliberations of the Commission any phase of the question,

four committees were appointed at the first meeting to deal respectively with:—

- (1) Education and legislation,
- (2) Location of tuberculosis,
- (3) Dissemination,
- (4) Disposition of tuberculous animals.

The appointment of these committees proved to be of the greatest possible value in concentrating the energies of the various members on those branches of the subject with which they were most familiar, and their reports presented at subsequent meetings enabled the Commission to reach satisfactory conclusions much more rapidly than would otherwise have been the case.

As a means of furnishing information as to the reasons for these conclusions and the manner in which they were reached, the Commission would recommend that the reports of the committees should be published as an appendix to this report.

The Commission recognizing after careful study that the tuberculin test is the fundamental factor in any policy having for its object the control of bovine tuberculosis, decided that a pronouncement to that effect should properly occupy a foremost place.

Based on the information contained in the reports of its Committees and on such other information as was brought out in the general discussions of the Commission, the following resolutions were adopted for presentation to the American Veterinary Medical Association.

RESOLUTION 1. DISSEMINATION

As a general policy to be observed all contact between tuberculous and healthy cattle and between healthy cattle and stables, cars, etc., which may contain living tubercle bacilli should be prevented. To accomplish this the following specific recommendations are made:—

1. There should be no sale or exchange of animals affected

with tuberculosis except for immediate slaughter or for breeding purposes under official supervision.

2. That the managements of live stock shows should give preference to cattle known to be free from tuberculosis, either by providing special classes for such cattle or in some other practical way, and should also take every precaution to prevent contact between such animals and those not known to be free from disease.

3. All live stock shippers should take every precaution to see that cars furnished are thoroughly cleansed and disinfected before use.

RESOLUTION 2. TUBERCULIN TEST

1. That tuberculin, properly used, is an accurate and reliable diagnostic agent for the detection of active tuberculosis.

2. That tuberculin may not produce a reaction under the following conditions:—

- (a) When the disease is in a period of incubation.
- (b) When the progress of the disease is arrested.
- (c) When the disease is extensively generalized.

The last condition is relatively rare and may usually be detected by physical examination.

3. On account of the period of incubation and the fact that arrested cases may sooner or later become active, all exposed animals should be retested at intervals of six months to one year.

4. That the tuberculin test should not be applied to any animal having a temperature higher than normal.

5. That any animal having given one distinct reaction to tuberculin should thereafter be regarded as tuberculous.

6. That the subcutaneous injection of tuberculin is the only method of using tuberculin for the detection of tuberculosis in cattle which can be recommended at the present time.

7. That tuberculin has no injurious effect on healthy cattle.

RESOLUTION 3. EVIDENCE FROM TUBERCULIN TEST

That a positive reaction to tuberculin in any properly conducted test, official or otherwise, in any animal in any herd, shall be considered evidence sufficient upon which to declare the herd to be infected.

RESOLUTION 4. COMPULSORY NOTIFICATION

That this Commission recommends the passage of legislation providing for the compulsory notification by owners and by veterinarians of the existence of tuberculosis in a herd, whether such existence be made known by detection of clinical cases or by the tuberculin test.

RESOLUTION 5. LOCATION THROUGH SLAUGHTER

This Commission recognizes that the discovery of tuberculosis in animals slaughtered for food purposes furnishes one of the best possible means of locating the disease on the farm, and therefore, recommends the adoption of some system of marking, for purposes of identification, all cattle three years old and over, shipped for slaughter.

As tuberculosis of hogs is almost invariably due to bovine infection this recommendation should also be made to apply to hogs of any age shipped for slaughter.

It is further recommended that the discovery of tuberculosis in animals coming under government inspection should be used whenever identification is possible, as a means of locating infected herds and premises. All such cases should be reported to the proper authorities for control action.

**RESOLUTION 6. DISPOSITION OF TUBERCULOUS ANIMALS
THE COMMISSION PLAN**

1. As a general policy in the eradication of tuberculosis the separation of healthy and diseased animals, and the construction of a healthy herd are recommended.

In order to accomplish this, the following recommendations are made:—

(1) If the herd is found to be extensively infected, as shown by the tuberculin test or clinical examination, even the apparently healthy animals in it should be regarded with suspicion, until they have been separated from the reacting animals for at least three months.

If after the expiration of this time they do not react to the tuberculin test, they may be considered healthy and dealt with accordingly.

It is recommended that a herd extensively infected should not be treated by the method of general separation, but that the construction of a new herd from the offspring only is advisable.

(2) If the herd is found, by either or both of the above methods, to contain a relatively small proportion of diseased animals separation of the diseased animals from the healthy animals, and the construction of a sound herd from the healthy animals, and the offspring of both, is advocated.

As a working basis in carrying out these principles, we advise.

(a) That herds containing fifty per cent or more of diseased animals be treated as coming under section one.

(b) That herds containing under fifteen per cent of diseased animals be treated as coming under section two.

(c) That herds falling between these figures be graded according to the option of the owner.

(d) That it shall be the prerogative of the owner to reject either plan and have his herd dealt with by removal and slaughter of diseased animals, with or without compensation, according to the public policy in operation.

2. That when by any means the officials properly charged with the control of tuberculosis become aware of its existence in a herd to which a policy of slaughter and compensation cannot reasonably be applied, such herd must be dealt with by the owner, under government supervision, on the principle of the separation of all sound animals from those affected. Such

separation must be effected by treating the whole herd as diseased, and rearing the calves separately, either on pasteurized milk or the milk of healthy cows, or when the number of those affected is so small as to warrant such a course, by the application to the whole herd, from time to time, under official supervision, of the tuberculin test, and the entire segregation of all animals found to react.

In the event of any owner refusing or neglecting to adopt either of the above methods, his entire herd to be closely quarantined, and sales therefrom to be entirely prohibited.

3. That a policy of compensation be recommended as useful and usually necessary as a temporary measure.

4. That, when slaughter is necessary, in order to avoid economic loss, every effort should be made to utilize as far as possible the meat of such animals as may be found fit for food on being slaughtered under competent inspection.

5. The details of the Commission Plan will be found fully set forth in the Appendix to this report.

RESOLUTION 7. PREVENTION

1. That, with the object of preventing the spread of infection, persons buying cattle for breeding purposes or milk production should, except when such purchases are made from disease free herds which have been tested by a properly qualified person, purchase only subject to the tuberculin test. In order to assist in the proper carrying out of this suggestion, the Commission recommends that official authorities should adopt such Regulations as will prevent the entry to their respective territories of cattle for breeding purposes or milk production unless accompanied by satisfactory tuberculin test charts.

2. That all milk and milk by-products used as food should be properly pasteurized unless from cows known to be free from tuberculosis.

RESOLUTION 8. CONTROL OF TUBERCULIN TEST

That this Commission recommends the passage of legislation which will prevent the sale, distribution or use of tuber-

culin by any person other than those acting with the full knowledge, or under the direction, of official authorities.

RESOLUTION 9. EDUCATION

As a clear knowledge of the cause and character of tuberculosis among animals, the modes of dissemination, its significance as an economic and as a public health problem, underlie an intelligent adherence to the principles that must be observed in all efforts for eradication, as well as the establishment of proper cooperation in the great work between physicians, veterinarians, live stock owners, legislators, and the public generally, it is recommended that a widespread campaign of education be undertaken. To accomplish this end it is recommended that first of all a simple pamphlet on bovine tuberculosis be written, in which the language used shall be of such character that every person of average intelligence shall be able to read it without being mystified by technical terms or phrases. This pamphlet should be published with the endorsement of the American Veterinary Medical Association and the special endorsement and consequent authority of the International Commission on Bovine Tuberculosis Control.

RESOLUTION 10. PUBLICITY

In concluding its work the Commission desires to especially appeal to the press, metropolitan, agricultural and local, to join in the work of extending as much as possible among the people the conclusions here arrived at. The vital importance of the life of farm animals to the welfare of all classes of society needs no argument in its support. The aim and sole purpose which has actuated this Commission has been to arrive at the soundest conclusions possible in the light of the best knowledge obtainable.

RESOLUTION 11. LEGISLATION

It is recommended that legislation regarding the control and eradication of tuberculosis among domestic animals be made uniform; that the laws of the United States and Canada

and other American countries for the admission into America of animals from without be made stringent and as much alike as possible; and that the laws governing the interstate and inter-provincial movement of cattle and that between different American countries be harmonized.

The laws governing inter-state and inter-provincial movement of cattle should be of such character that every state and every province will be free in its eradication work from unnecessary difficulties due to the existence of the disease in other states and provinces.

Legislation is especially required to prevent the various frauds which interfere with the satisfactory use of tuberculin as a diagnostic agent for tuberculosis, as well as for official supervision over all tuberculin sold to be used by veterinarians and others.

RESOLUTION 12. SANITATION

In the eradication of tuberculosis it should be kept in mind that, in addition to protecting animals against exposure to tubercle bacteria, it is desirable to make them as resistant to infection as possible. This can be done by stabling them in clean disinfected and properly ventilated and lighted barns, giving them abundant clean water and nutritious food, a sufficient amount of daily exercise in the open air, and attending generally to those conditions which are well known to contribute to the health of animals.

The daily removal of manure from stables, and water tight floors and good drainage in stables are urgently recommended.

Young stock particularly should be raised as hardy as possible and should be accustomed to liberal exercise and living in the open.

RESOLUTION 13. IMMUNIZATION

That as none of the various methods for the immunization of animals against tuberculosis have passed sufficiently beyond the experimental stage the Commission is unable to endorse any of these for practical use at the present time.

RESOLUTION 14. ANIMAL TUBERCULOSIS AND PUBLIC HEALTH

While the members recognize that the subject with which this Commission is primarily intended to deal is the control and eradication of tuberculosis among animals as an economic problem they cannot feel satisfied without declaring their recognition of the fact that tuberculosis among animals is also an important public health problem. Considered as such, the eradication of tuberculosis among animals should have the approval and support of all those persons who are interested in curtailing human suffering and prolonging human life.

RESOLUTION 15. GENERAL STATEMENT

The members of the Commission wish to be clearly understood that they recognize the limitations of a report necessarily based on actual and not on theoretical conditions. They fully realize that in the event of the policy of which their recommendations form the framework, being anywhere adopted even in its entirety, much greater benefit will be derived, at least for some time, from its educative than from its executive features.

The control to say nothing of the eradication of bovine tuberculosis, is impossible of achievement, without the hearty cooperation of all the men who are actually engaged in the cattle industry. In order to secure this cooperation, it will doubtless be necessary, in most communities, to carry on an active and prolonged educational campaign.

It is apparent that in the dissemination of practical and reliable information regarding the disease, it will be possible to employ a very large variety of methods. Many of these methods, such as bulletins, lectures and actual demonstrations of disease, having already been found valuable, will doubtless continue to be largely used.

It must not be forgotten however, that in this, as in any other educative process, a measure of disciplinary control is essential to success.

Needless to say such control can be secured only by the

passage of legislation which, while clear and comprehensive must, at the same time, be sufficiently conservative to avoid exciting alarm or arousing antagonism on the part of owners especially of valuable herds.

The best law ever framed can be made an utter failure by stupid or injudicious administration, while, on the other hand, the most drastic legislation can be rendered acceptable if enforced with reasonable tact and diplomacy.

Provided therefore, that these qualities, combined with integrity, thoroughness, and determination, are available for administrative purposes, the members of the Commission are convinced that the enforcement of a law based on their recommendations, will prove to be by far the most powerful and effective educational agency which could possibly be employed.

In concluding its Report the Commission would suggest that the Association should make such provision as may be necessary to carry on the work either by continuing the Commission as at present constituted or with such changes in the personnel as may be considered desirable.

REPORT OF THE COMMITTEE ON EDUCATION AND LEGISLATION

The Subcommittee on Education respectfully submit the following:—

Bovine tuberculosis has become widely distributed throughout the United States and Canada and it has been determined that efficient systems or methods for its eradication and prevention either under the supervision of the state or nation or by the cattle owners themselves are of necessity based on a knowledge of the nature of the disease and its means of dissemination.

Experience has shown that the principles of eradication and prevention may be successfully applied by individual owners of infected cattle, independent of state assistance.

Such individual aid is essential in conjunction with state or national assistance in the prompt eradication of the disease

from infected herds and the prevention of its entry to non-infected herds.

Therefore it is the sense of this committee that every possible means should be employed for educating the cattle owners and the general public concerning the nature of tuberculosis; the care and precautions necessary to prevent its entrance into herds already free from the disease; and in methods for its eradication from herds where it now exists.

Further, this committee approves of the following methods for instructing laymen, practicing veterinarians, practitioners of human medicine and health officers in the nature and control of bovine tuberculosis, namely:

1. By the publication in agricultural and dairy papers of short accurately and carefully prepared articles on bovine tuberculosis.
2. By publication of appropriate articles on bovine tuberculosis in veterinary, medical and sanitary papers and journals.
3. By recommending to agricultural societies, granges and directors of farmers' institutes and unions and especially those interested in creameries and cheese factories that lectures on bovine tuberculosis, its nature and control, be made a part of their programs and that so far as practicable, demonstrations be held.
4. That those having in charge the arrangement of town, county and state fairs be requested to provide lectures on bovine tuberculosis, and if practicable to hold public demonstrations, at their annual meetings.
5. By placing a copy of the report of the commission in the hands of the deans or directors of all veterinary and medical colleges and schools of sanitary science in the United States and Canada with recommendations that special emphasis be placed in their courses of instruction on the nature of bovine tuberculosis and methods for its control.
6. That a pamphlet dealing with the nature of bovine tuberculosis and methods for its control should be written in language intelligible to the layman. This pamphlet should

have the approval of this commission and the endorsement of the American Veterinary Medical Association. It should be published for free distribution.

7. That Departments of Agriculture, state veterinarians, live stock sanitary boards and others interested in the official control of bovine tuberculosis be requested to promote as much as possible the educational features of their work, with the object of obtaining more support and cooperation from cattle owners.

The methods suggested for carrying out an educational propaganda are not to be considered at the exclusion of any and all other ways by which the public may become informed on the nature of bovine tuberculosis, its great economic importance and the necessity for an intelligent and united effort on the part of cattle owners and those having charge of the control of animal diseases to eradicate this great scourge.

The Committee is of the opinion, from the history of the legislation regarding bovine tuberculosis in those states and countries which have attempted to deal radically with the problem, as well as from the special information which has been furnished by this committee to its members, and the light thrown upon the subject in the discussions at its several meetings, that in order to avoid friction and failure, all important legislation with reference to tuberculosis must be prepared with due consideration for the condition of public sentiment and information on this subject. That tuberculosis control work should be developed in a progressive way. That tuberculin tests made at a distance for public recognition (for example, in other states or foreign countries) can only be done satisfactorily by official veterinarians. That the Delépine or Manchester plan of tuberculosis free areas gradually extended seems worthy of cautious trial.

(Signed) M. H. REYNOLDS, *Chairman.*
W. D. HOARD.
J. G. RUTHERFORD.

GOV. HOARD'S REPORT

EDUCATIONAL MEANS FOR THE SUPPRESSION AND CONTROL
OF BOVINE TUBERCULOSIS

Mr. President and Gentlemen of the Commission:

I place a high value on the work this Commission may do if performed wisely, in shaping the conviction and purpose of the people of Canada and the United States concerning the prevention and control of bovine tuberculosis.

As yet, that conviction is but little more than an ill defined dread of something not clearly understood by the great mass of farmers. Added to this dread is a hope stronger yet, that the evil is not as great as has been asserted; that it is a scare that will soon pass over. As yet, in the minds of farmers and breeders generally, especially in those localities where demonstration work has not been had, there is a strong under current of conviction that all this talk about the disease is an interested plea of the veterinarians, that the trouble does not amount to much if the doctors and editors would hold their tongues and pens.

Just as long as this bank of fog exists, it will control all legislation and individual effort, to get rid of the difficulty. At the bottom of the matter is a wide spread ignorance on the part of farmers as to the danger that threatens them; it is difficult to arouse them out of their conservatism, for as yet, all they know about it is talk.

The conservatism of intelligence is vastly different from that which exists because of a lack of knowledge. The first demands more light; the latter dreads light.

From what I have seen in Wisconsin, I am convinced that the most powerful aid to that action against the disease which this Commission is so anxious to bring about, is public demonstration. One animal slaughtered before a body of farmers, and the diseased parts exposed to their plain view,

is worth more to foster conviction and inspire effort than anything else that can be done. If the federal and state governments would devote means for this demonstration work, it would prove a most powerful educator. Public agitation, in farmers' gatherings, and the talk of the Agricultural Press is useful mainly, in keeping alive an interest in the subject. But gentlemen, we must remember that with the majority of men, a large majority,—“Seeing is believing”.

I believe therefore, that this Commission should use its influence in urging legislation by municipalities, and state and national legislatures for the spread and support of this demonstration work. Great care must be exercised, however, to select only such animals as will amply show forth the ravages of the disease. The great progress we have made in legislation in Wisconsin, and in securing wide spread acquiescence in the use of the tuberculin test, would never have come had it not been for a large number of public demonstrations held in various parts of the state.

We have gone as far as this in legislation: After December 1, 1910, all animals sold for breeding or milking purposes, must first be tuberculin tested. This, I believe, is a step further in advance than has been taken by any other state. It shows well the tone and temper of our farmers and the work which has been done to acquaint them with a true understanding of the situation. It is needless for me to say that if they are for the law, or any law, it goes; if they are against it, it is at best a dead letter. It is worth a great deal in the promotion of such objects, to have a live stock sanitary board in a state that will take a hold and lead in this work. In too many instances these organizations are purely negative, in their influence, and so nothing is done. There is a notable lack of funds to bear the expense of demonstration work. The farmers everywhere would willingly be taxed for its support. Municipalities could well afford to have such expense for the sake of the education it would afford to consumers of meat and dairy products.

In conclusion, I would urge upon this Commission that special emphasis be placed upon the promotion of public exhibitions of diseased cattle before and after slaughter, as the most powerful means of education concerning the nature and danger of bovine tuberculosis.

(Signed) W. D. HOARD.

REPORT OF COMMITTEE ON LOCATION OF TUBERCULOSIS IN CATTLE

Your committee on the location of tuberculosis in cattle desires to submit the following as its report upon this subject. Though we are all agreed that no method for detecting tuberculosis in cattle equals the tuberculin test, we are forced to recognize that the universal application of the test under existing conditions is practically and economically impossible. The number of cattle to be tested, for example, is so great that, if all the available veterinarians and all such other persons as may be trusted to make tuberculin tests should be started on this work at once, and kept at it, years would pass before all the cattle in the United States and Canada could be tested even a single time. Consequently, our efforts to locate tuberculosis among cattle should depend primarily upon other means than the tuberculin test.

The tuberculin test should be regarded as having only an incidental value in the systematic work of locating tuberculosis, and as being of preeminent importance when we undertake the determination of the extent to which the disease is prevalent at any point in any herd where it has been located by other means or, incidentally by the tuberculin test.

In the order of seeming importance the means of location may be placed as follows:

I. NOTIFICATION

A law should be enacted requiring any and every person having knowledge of the existence of a case of tuberculosis

among cattle to report the same without delay to some proper designated authority. Such a law would be practically equivalent to the obligatory reporting of all clinical cases of tuberculosis which must be recognized as the most serious disseminators of tubercle bacilli and propagators of tuberculosis.

Since all cases of tuberculosis that are centers from which infection is being scattered, gradually become clinically recognizable, obligatory notification of all recognized cases of tuberculosis would alone in the course of a few years locate the majority if not all badly diseased herds. It would certainly locate tuberculous cattle and herds faster than they can be handled for some years to come.

II. EVIDENCE THROUGH MEAT INSPECTION

An effort should be made to trace tuberculous animals back from slaughter-houses to the farms from which they were derived. This is important because if the well-conditioned animals which go to slaughter for meat are tuberculous it is probable that among the animals retained on the farm some active disseminators of tubercle bacilli exist, which are retained at the farm either through ignorance or a false idea of economy.

Meat inspection has already done much to establish infected areas from which tuberculous animals have been sent to market. At present, however, it is difficult to trace animals to farms from which they were shipped, and some method of identification by means of which any animal found on the killing floor to be tuberculous can be traced to its place of origin is greatly to be desired. A federal law requiring appropriate tagging, branding or otherwise identifying all hogs and dairy cattle moving interstate for slaughter, and state laws compelling similar identity marks for these animals moving within the state for slaughter, would be the means of locating a large proportion of the centers of tuberculosis. Experimental work of this character which has been carried out in the past has given very interesting results. For instance, when the

occurrence of tuberculosis among hogs at an abattoir is followed up by a tuberculin test of the cattle on the home farm it practically always discloses tuberculosis among these animals. Like much other evidence this encourages us to believe that tuberculosis among hogs will cease to exist as an economically important problem as soon as we succeed in controlling the bovine source of tubercle bacilli.

III. THE TUBERCULIN TEST

When the tuberculin test is applied to cattle for any purpose it should be clearly understood that the reacting animals are to be regarded in every sense of the word as recognized cases of tuberculosis, which under an obligatory notification law, must be reported at once to the proper authority. In this way tuberculin will serve as an important means of locating tuberculosis among cattle that are tested for reasons like the following:

- (1) To obtain healthy animals for export.
- (2) To make sure that animals imported are free from tuberculosis.
- (3) To make sure that animals intended for interstate movement are free from tuberculosis. And here we would like to suggest that the states should protect themselves as much as possible against bovine tuberculosis by insisting that no new cattle shall be brought in until they have been shown by the tuberculin test to be free from tuberculosis. The time we may hope is not far off when even breeders of exceptionally fine strains of blood will begin to realize that the very best blood coupled with tuberculous infection is an article to be shunned, not because we wish to imply that tuberculosis is hereditary, but because we know how readily it is conveyed from animal to animal by contact.
- (4) To obtain milk from animals shown in the most conclusive manner to be free from tuberculosis, irrespective of whether the milk is intended for special certification or for more general or regular city use.

(5) To satisfy an owner of cattle that his herd is free from tuberculosis or to give him the information he needs to clean his herd from disease.

In whatever way the tuberculin test is applied, or for whatever purpose, all positive reactions obtained should be regarded as placing the reacting animal in the category of recognized cases of tuberculosis, which must be reported under a notification law.

As the newer methods of applying tuberculin for test purposes have not been found to be as reliable as the older, subcutaneous method, they cannot be advocated. The ophthalmic and cutaneous tuberculin tests may have a value in some special cases, as for example, where doubt exists about the reliability of a subcutaneous test because an animal may have been subjected to some pernicious manipulation. In this sense these latter modes of applying tuberculin should be kept in mind.

IV. EXAMINATION OF MATERIAL FROM CATTLE AND HERDS

The valuable evidence that may be obtained as to the location of tuberculosis through the examination of milk, cream, butter, centrifuge slime and other products and materials from cattle should not be neglected, especially when these examinations are made by health officers and others for the protection of public health, and are followed up by the inspection of the animals and the character of their environment as a routine procedure. Such inspections are constantly becoming more prevalent in various sections of the United States and Canada.

V. MOST IMPORTANT SOURCES OF ANIMAL TUBERCULOSIS

Tuberculosis as it exists among the domestic animals of America, today, undoubtedly owes its primary introduction to the cattle of improved breeding that have been imported from European lands from time to time in the past, for the purpose of improving the native stock of the country. No particular breed is to be incriminated in this charge, as several

of the most prominent and popular breeds have been found guilty of furnishing tuberculous individuals to the best American herds on repeated occasions. The knowledge that infection has taken place from these sources in the past affords us a valuable indicator of the points where search should be made in our efforts to detect the cases of tuberculosis that exist today upon the farms of the country. First of all then, attention may be directed toward all herds of pure bred cattle whether of beef or dairy type, especially to those from which cattle are sold, either by private or public sale, and from which cattle are thus distributed to various parts of the country; also to herds from which members are exhibited at fairs and exhibitions; and herds which keep males for custom service.

In addition to these herds of pure bred cattle there are many others to which well bred stock has been added for the purpose of grading up and improving the quality of the individuals of the herd.

These in some instances have received the infection of tuberculosis with the new animals from which such great benefits had been expected, and these herds of well graded cattle should also be regarded with suspicion until they have been proved to be free of tuberculosis. Next in order should come all dairy cattle, but the methods by which the disease may be located in these herds have been discussed above.

(Signed) JOHN R. MOHLER, *Chairman.*
J. W. FLAVELLE.
C. A. HODGETTS.

REPORT OF COMMITTEE ON DISSEMINATION OF BOVINE TUBERCULOSIS

The subcommittee on the dissemination of bovine tuberculosis respectively submits the appended report on the means for the dissemination of this disease, based on the present knowledge of the life history of the tubercle bacillus. The possible means for the dissemination of this disease are enumerated as follows:

1. The introduction into a sound herd of an animal or animals affected with tuberculosis (a) those with open tuberculosis (b) those in which the disease is in the period of incubation and (c) those in which the lesions are temporarily arrested.

The last group will not transmit the infection speedily and possibly may never do so. The first group is certain to spread the virus.

2. By feeding calves milk, whole or separated, buttermilk or whey, where the milk has come from tuberculous cows.

3. By bringing cattle suffering from open tuberculosis in contact with healthy ones at fairs, cattle shows and other exhibitions.

4. By shipping healthy cattle in cars not thoroughly disinfected, recently occupied by tuberculous cattle.

5. By placing healthy cattle in stables that have not been thoroughly disinfected and which were recently occupied by tuberculous animals, as frequently happens with the change of farm ownership or tenants.

6. Tuberculous animals which do not react to tuberculin such as those in the period of incubation or latent cases, but which develop active tuberculosis later, are frequently carriers of the virus although bought and sold as sound animals. These can not at present be differentiated from sound animals. Therefore all cattle coming from herds in which the disease exists should be considered as suspicious. The sound herd is the unit to deal with.

7. Tubercle bacilli may be transmitted by tuberculous cattle running in a pasture to healthy cattle in adjoining pastures where they are separated by a fence of such nature that the cattle may get their noses together.

8. Tuberculosis in cattle rarely, if ever, occurs through infection from (a) man, either directly or as a carrier of bovine tubercle bacilli, (b) from other species of animals, or (c) by infection from the droppings of crows, buzzards or other birds or carnivorous animals that have fed upon the carcasses of tuberculous cattle. It is the opinion of this committee that bovine

tuberculosis is spread largely through the introduction of tuberculous cattle into sound herds; by the feeding of calves with infected milk, or milk products; by exposing sound animals to infected ones at fairs, or other cattle shows; and by exposing them to infected cars and stables. There are other ways in which now and then it is possible that an animal may become infected but the means of dissemination mentioned in this paragraph are those to be guarded against in formulating efficient methods of control.

(Signed) V. A. MOORE, *Chairman.*
 E. C. SCHROEDER.
 M. P. RAVENEL.

REPORT OF COMMITTEE ON DISPOSITION OF TUBERCULOUS ANIMALS

Your committee on the Disposition of Tuberculous Animals begs to submit the following report:

In the work of control and eradication of tuberculosis in animals it is first of all of the utmost importance to establish the presence of the disease in all the affected cattle, since only by such a procedure will it be possible to guard the healthy and newly born animals from infection.

Fortunately we are in a position to determine with considerable certainty the vast majority of occult cases of tuberculosis in cattle, even the incipient cases, with the aid of tuberculin, and the clinical cases by physical examination. This alone constitutes a great advantage in the work of suppression of the disease. The tuberculin test should therefore be considered as a very important step in the eradication of tuberculosis. As a matter of fact all the recognized authorities on the subject are agreed on this point. Once the tuberculous animals are recognized consideration must be given to the most suitable and economical way of eradicating the disease from the herd. This naturally brings up the question of the disposition of the tuberculous animals, and in adopting any particular method one should be guided by the extent of the

infection of the herd, the quality of the affected animals, the sanitary condition of the premises, and last but not least, the owner's intelligence and knowledge of the subject. The latter information is necessary to determine if reliance can be placed on the owner to carry out minutely all the details which are essential in executing any particular method of eradication that may be decided upon. The owner's cooperation in this work is without doubt a very essential feature of this great task. For this reason a campaign of education of the farmers and stock raisers relative to the control of tuberculosis in which all the advantages of the eradication of tuberculosis must be impressed on them, would greatly facilitate this important campaign. It is a well known fact that any voluntary method of suppression by the herd owners themselves would bring about better and quicker results than when compulsory measures are enforced upon them by legislative enactments. Nevertheless the time has arrived when a campaign looking towards the control of this disease should be entered upon by the general government as well as the state and province. This campaign must reach in the first place all the clinical pulmonary forms of tuberculosis; then tuberculosis of the udder, intestines and uterus.

Having removed these exceedingly dangerous cases the balance of the tuberculous herd may be treated by the Bang system, which consists of the establishment of two herds of cattle, one containing the animals which react to tuberculin, and the other those that prove to be healthy. Each class of cattle is kept entirely separate from the other, in different stables when possible, and under the care of separate attendants, using separate utensils. The calves born of the diseased cows are removed from their mothers at birth and placed in the stable with the healthy animals where they are reared upon the milk of healthy cows or upon other milk which has been properly pasteurized. In this way the healthy portion of the herd constantly increases while the diseased animals are disposed of as rapidly as may be deemed necessary until

finally all of them are gone and the remaining herd is composed entirely of healthy cattle. The tuberculin test is applied to the healthy herds at regular intervals, annually or semi-annually, in order to detect any cases of latent tuberculosis or recent infection which may appear.

A modification of the Bang system is Ostertag's method of suppressing tuberculosis. This system demands only a clinical examination of the original herd with the elimination of all open cases of tuberculosis. The calves from the remaining cows are immediately removed and brought up on pasteurized milk in the same manner as in the Bang system and a new herd is thus established from the young stock. Healthy nurse cows could be used for these calves instead of feeding them on pasteurized milk. The tuberculin test is applied to this new herd at stated intervals in order that any cases of tuberculosis which may develop therein may be discovered promptly. Neither of these systems, however, has met with much favor in this country as it required a considerable length of time and care to create a herd free from tuberculosis by either of them. Nevertheless the inauguration of Bang's or Ostertag's method in herds of valuable animals whether they be dairy or beef breeds is unquestionably of an economic value and in such cases either of these systems should be encouraged. On the other hand, in ordinary beef or dairy herds the practice of Bang's or Ostertag's method in this country has not met with much encouragement, owing to the extraordinary supervision, time and labor, as well as the loss of market milk from the reacting cows which it involves.

In such herds the best ultimate results have thus far been obtained by the obligatory disposal of all the clinically affected cows and giving the dairyman the alternative either to pasteurize the milk from the remainder of his herd, or to be forced to refrain from selling the raw milk from the infected herd at all. In case he adopts the former method the herd composed of diseased and healthy cattle should be placed in quarantine under the supervision of sanitary authorities, and no sales

should be permitted from the herd excepting for immediate slaughter. The alternative method will compel him to dispose of his tuberculous animals in the case he refuses to pasteurize the milk. The suppression of tuberculosis could be greatly facilitated and the cooperation of many of the herd owners could be gained by a provision by which a certain percentage of indemnity could at least for a term of years be paid for the condemned animals. The scale for such an indemnity should be arranged in accordance with the final disposition of the carcass under competent inspection.

Another method of eradication should receive serious consideration as being of value in some localities. This is known as the Manchester system, which is either the Ostertag or Bang system applied to localized areas or even individual farms, from which centers the work progresses to surrounding or neighboring districts and farms.

Inasmuch as the animals affected with clinical tuberculosis are the greatest sources of danger in the dissemination of the disease, compulsory reporting of such cases should be inaugurated by the state, as is now done in many places in the control of human tuberculosis. Mandatory reporting of these cases and their prompt slaughter are very essential, as only by the elimination of these exceptionally dangerous cases can it be hoped to take up all the other details by which a successful control of bovine tuberculosis may be accomplished.

In conclusion your Committee, having regard to the disposition of pure bred cattle, or valuable animals kept for either breeding or dairy purposes, would strongly recommend a system requiring the removal of all clinical tuberculous animals from the herd, the segregation of all calves from the remaining cows in order to establish a new, clean herd, the use of tuberculin tested nurse cows or pasteurized milk for these calves, and the periodic application of tuberculin to this newly established herd, as the only thoroughly reliable one.

(Signed) W. C. EDWARDS, *Chairman.*
 JOHN R. MOHLER.
 FREDERICK TORRANCE.

THE COMMISSION'S RECOMMENDATIONS ON ERADICATION—A COMPOSITE OF THE METHODS OF BANG AND OTHERS.

The Commission after stating the known facts regarding the nature of tuberculosis and enumerating the principles to be observed in its prevention and eradication, recommends the following plan of procedure: It is recognized that in several points there are opportunities, in order to meet individual needs, to change or modify the directions herein given. It is understood, however, that whenever such modifications are made they should conform in the greatest detail to the principles laid down in the report of this Commission. The plan has for its purpose the conservation of the herd whenever that is possible.

The control of bovine tuberculosis involves a definite procedure under two distinct and different conditions, namely: (1) where a herd of cattle is free from tuberculosis and it is to be kept so, and (2) where one or more animals in the herd are infected and the purpose is to eradicate the disease and establish a sound herd.

PROCEDURE UNDER CONDITION ONE

The prevention of tubercular infection in cattle, free from tuberculosis, consists simply in keeping tuberculous cattle or other animals away from the sound ones; in keeping tuberculous animals out of pastures, sheds or stables where the sound ones may be kept. Healthy cattle should not be exposed to possible infection at public sales or exhibitions. Raw milk or milk by-products from tuberculous cows should not be fed to calves, pigs, or other animals. Cars that have not been thoroughly disinfected should not be used for the transportation of sound cattle. Cattle that are purchased to go into sound herds should be bought from healthy or sound herds only.

PROCEDURE UNDER CONDITION TWO

The eradication of tuberculosis from infected herds requires for conservation of the herd different procedures according to

the extent of the infection. For a guide to the control of the disease, tuberculous herds may be divided into three groups, namely:

- I. Where fifty per cent or more of the animals are infected.
- II. Where a small percentage (15% or less) of the animals are affected.
- III. Where a larger number (15% to 50%) of the animals are diseased.

In eliminating tuberculosis from infected herds the following procedure is recommended:

GROUP I

Herds where a tuberculin test shows fifty per cent or more of the animals to be infected should be treated as entirely tuberculous. The procedure here is as follows:

1. Eliminate by slaughter all animals giving evidence of the disease on physical examination.
2. Build up an entirely new herd from the off-spring. The calves should be separated from their dams immediately after birth and raised on pasteurized milk or on that of healthy nurse cows. This new herd must be kept separate from any reacting animals.
3. The young animals should be tested with tuberculin at about six months old, and when reactors are found at the first or any subsequent test—the others should be retested not more than six months later. When there are no more reactors at the six months' test annual tests should thereafter be made. All reacting animals should at once be separated from the new herd and the stables which have been occupied thoroughly disinfected.
4. When the newly developed sound herd has become of sufficient size the tuberculous herd can be eliminated by slaughter under inspection for beef.

GROUP II

1. The reacting animals should be separated from the non-

reacting ones and kept constantly apart from them at pasture in yard and in stable.

(a) PASTURE. The reactors should be kept in a separate pasture. This pasture should be some distance from the other or so fenced that it will be impossible for the infected and non-infected animals to get their heads together.

(b) WATER. When possible to provide otherwise reacting cattle should not be watered at running streams which afterwards flow directly through fields occupied by sound cattle. The water from drinking troughs used by infected animalsshould not be allowed to flow into stables, fields or yards occupied by sound animals.

(c) STABLE. Reacting cattle should be kept in barns or stables entirely separate from the ones occupied by the sound animals.

2. Calves of the reacting cows should be removed from their dams immediately after birth. Milk fed these calves must be from healthy cows, otherwise, it must be properly pasteurized. These calves should not come in contact in any way with the reacting animals.

3. The non-reacting animals should be tested with tuberculin in six months, and when reactors are found at the first six months, or any subsequent test, the others should be retested not more than six months later. When there are no more reactors at the six months' test, annual tests should thereafter be made. All reacting animals should at once be separated from the new herd and the stables which they have occupied thoroughly disinfected.

4. The milk of the reacting animals may be pasteurized and used.

5. Any reacting animal which develops physical symptoms of tuberculosis should be promptly slaughtered.

6. An animal that has once reacted to tuberculin should under no circumstances be placed in the sound herd.

7. As soon as the sound herd has become well established, infected animals should be slaughtered, under proper inspection.

GROUP III

Herds that come within this group should be dealt with either as in Group II, where the herd is separated, or as in Group I, where all of the animals are considered as suspicious and an entirely new herd developed from the offspring.

GENERAL PRECAUTIONS

In ALL cases animals that show physical evidence of the disease should be promptly eliminated. They should be destroyed if the disease is evidently far advanced, if not, they may be slaughtered for food under proper inspection.

All milk from tuberculous cows that is used for food purposes should be thoroughly pasteurized. This means that it must be heated sufficiently to kill or to render harmless, any tubercle bacteria that may be present in it. For this, it is necessary to heat the milk for twenty minutes at 149° F. or for five minutes at 176° F. It is important that pails or other utensils used in carrying the unpasteurized milk should not be be used, unless previously sterilized, for storing the milk after it is pasteurized.

When diseased animals are found, the stables from which they are taken should be thoroughly cleansed and disinfected. To accomplish this, all litter should be removed; floors, walls and ceilings carefully swept and the floors together with mangers and gutters, thoroughly scrubbed with soap and water. Thorough cleaning before the application of the disinfectant, cannot be too strongly emphasized. After cleansing, the disinfectant should be applied. A five per cent (5%) solution of carbolic acid, a 1-1,000 solution of corrosive sublimate or a four per cent (4%) solution of sulphuric acid may be used.

When the stable can be tightly closed, formaldehyde gas properly used is reliable and satisfactory.

If tuberculous cattle have been kept in a small yard the litter should be removed, the surface plowed and the fencing and other fixtures thoroughly cleansed and disinfected.

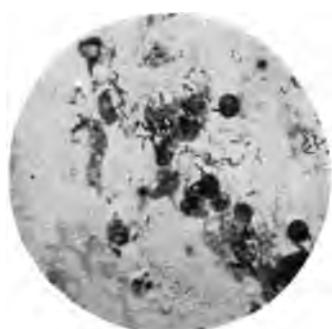
ILLUSTRATIONS

PLATE I.

Tubercle bacteria. Photographs of tubercle bacteria. 1. Bovine variety, from a young culture on glycerin agar. 2. Bovine variety from the mouth of a cow having advanced pulmonary tuberculosis. 3. Avian tubercle bacteria from a glycerin agar culture. (X about 1000.)



1



2



3

PLATE I. TUBERCLE BACTERIA

PLATE II.

Cultures of tubercle bacteria. 1. Growth of bovine variety of *Bacterium tuberculosis* on glycerin agar. 2. Growth of same organism on egg medium.
(Natural size.)



PLATE II. CULTURES OF TUBERCLE BACTERIA (Bovine variety)

PLATE III.

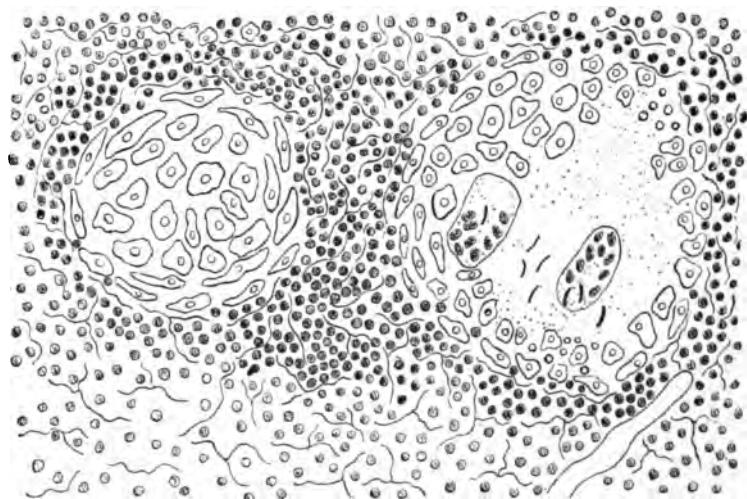
Growth of tubercle bacteria on glycerin bouillon. A photograph of the surface growth of bovine tubercle bacteria on glycerin bouillon. It shows the pushing up of the growth along the sides of the flask at the margin. The wrinkled surface of the growth is slightly in evidence.



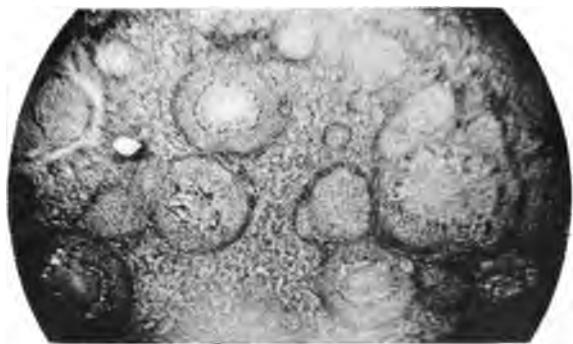
PLATE III. CULTURE OF TUBERCLE BACTERIA ON GLYCERIN BOUILLON
(Natural size)

PLATE IV.

Structure of tubercle. 1. A drawing of a section of very young tubercles in the spleen (After Thoma). The tubercle at the left shows simply epithelioid cells, the one at the right shows the necrotic center with giant cells containing tubercle bacteria and the zone of epithelioid cells surrounded by a zone of small round cells (lymphocytes). 2. A photograph of a section of a chicken's liver showing several small tubercles. The necrotic center and surrounding zone of epithelioid and giant cells and the one of round cell infiltration surrounding it. (X about 10.)



1

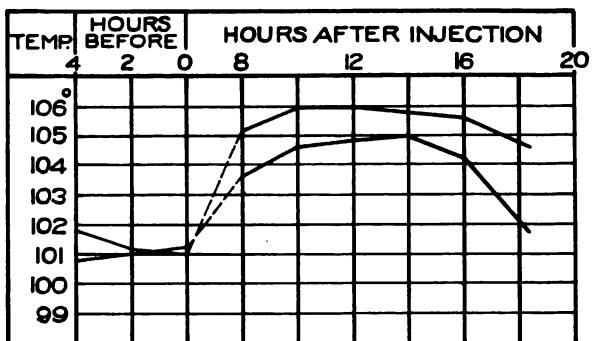


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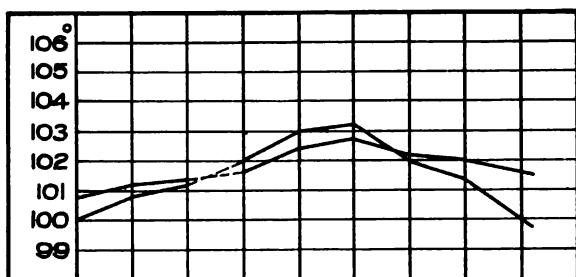
PLATE IV. STRUCTURE OF YOUNG TUBERCLES

PLATE V.

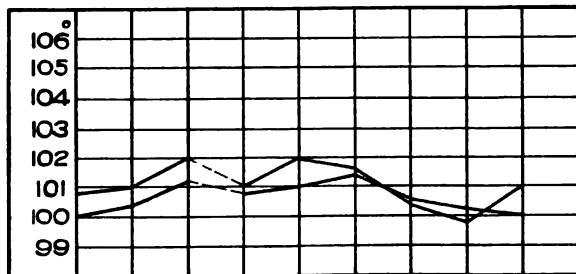
Temperature curves. After tuberculin. 1. Shows the temperature curves in unquestioned tuberculin reactions. 2. Shows the temperature curves when the elevation is slight and there is doubt whether they are reactions or not. 3. The normal temperature.



1



2



3

PLATE V. TEMPERATURE CURVES.

PLATE VI.

Bronchial glands. Trachea and bronchial tubes of bovine lungs showing attached bronchial glands. (a-a¹) Supply right and left caudal lobes, (b-b¹) supply r. and l. ventral lobes, (c-c¹) branches of the right supernumerary bronchus, (c²) supply left cephalic lobe, (d) branch of azygous lobe, (e) trachea. A. Left bronchial lymph gland. B. Right bronchial lymph gland. C. Lymph gland base of supernumerary bronchus. D. Gland often between bronchi. The glands A. to D. are often involved (Smith)



PLATE VI. BRONCHIAL GLANDS (Smith)

PLATE VII.

Tuberculous lung. This is a photograph of a section of the anterior lobe of a cow's lung advanced in tuberculosis. The entire lung tissue is involved. The tuberculous masses are surrounded in some instances by a quite thick band of connective tissue. A large part of the tissue is calcified. This is shown by the light or whitish points. (Natural size.)

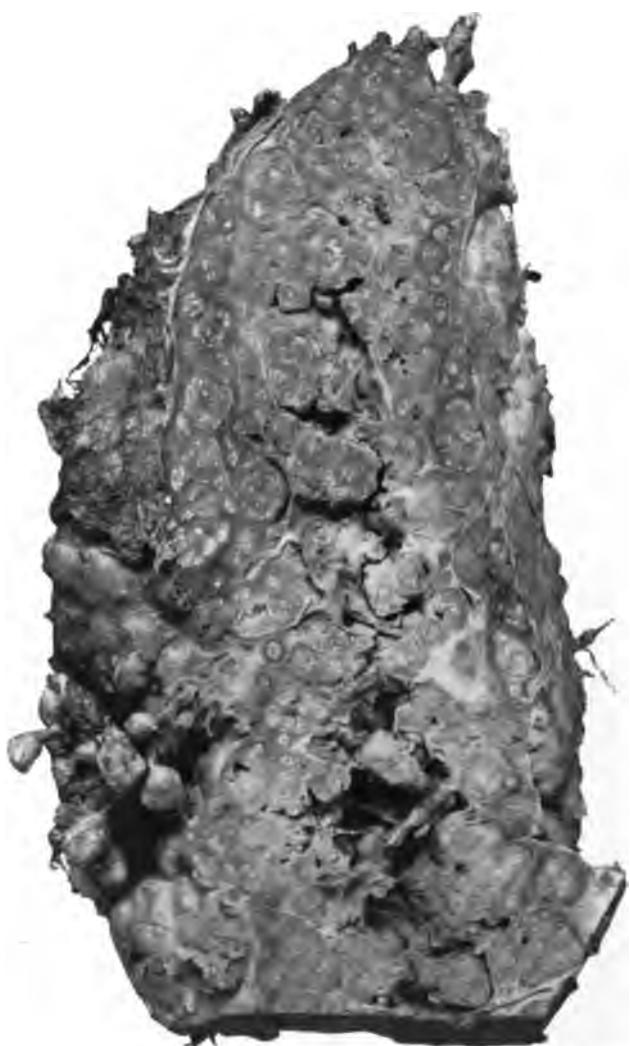


PLATE VII TUBERCULOUS LUNG

PLATE VIII.

Tubercle opening into bronchus. This shows a section through a bronchus where at point (a) the tuberculous tissue has extended into the bronchus making it possible for the tubercle bacteria from the tuberculous area to pass into the bronchus and through it to the mouth. From the mouth they are disseminated with the droolings or they are swallowed and appear in the intestinal contents. (Natural size.)



PLATE VIII. TUBERCLE DISCHARGING INTO BRONCHUS

PLATE IX.

Tuberculous lung, diaphragm and liver. This photograph shows a piece of the lung (a) attached to the diaphragm (b) by a mass of tuberculous tissue growing out from the serous membrane. The liver (c) is lying just beneath the diaphragm. The anterior surface of the diaphragm is covered with tuberculous nodules (d) which have fixed the margin of the lung to it. (Natural size.)

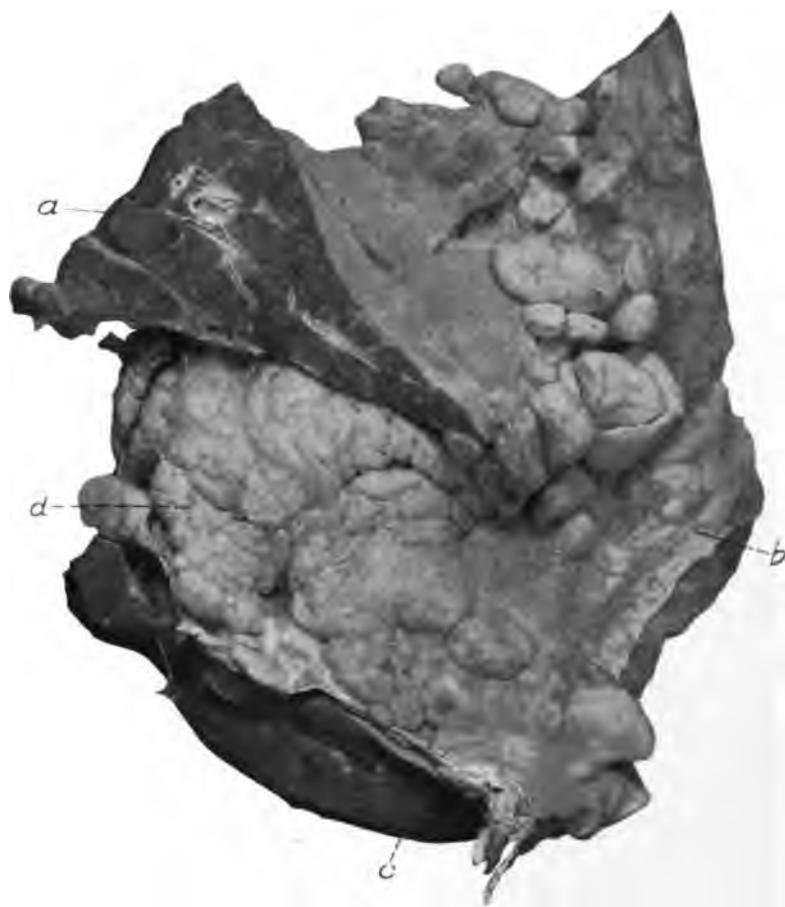


PLATE IX. TUBERCULOUS DIAPHRAGM

PLATE X.

Tuberculous nodules on lung. This is a photograph of a few large tuberculous nodules on the margin and surface of a cow's lung. The normal lung is shown at (a). The tuberculous masses which were calcified are shown at (b). (Natural size.)

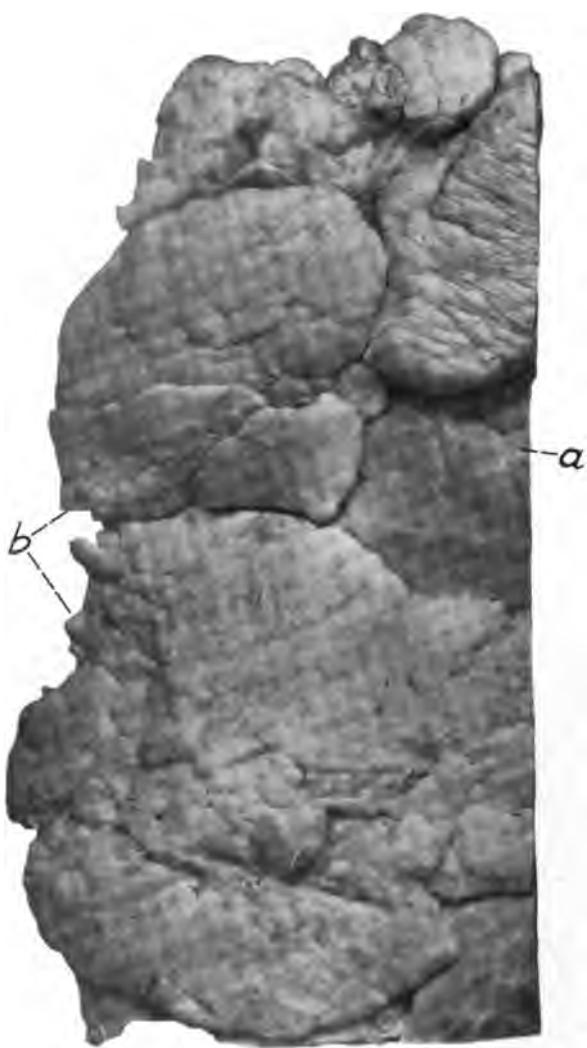


PLATE X. TUBERCULOUS GROWTH ON LUNG

PLATE XI.

Tuberculous pleura. This is a photograph of the tuberculous prominences or nodules that have developed on the pleura covering the ribs. (Natural size.)



PLATE XI. TUBERCLES ON PLEURA OVER RIBS

PLATE XII.

A cross section of a cow's heart. This is a photograph of a cross section of a tuberculous heart. It shows a thick tuberculous deposit surrounding the heart muscle. (a) Heart muscle of the right and left ventricles, (b) a layer of fat between the heart muscle and the tuberculous deposit (c) beneath the pericardium. This tuberculous deposit much of which is calcified surrounds the entire heart extending with about equal thickness from the apex to the base. (Slightly reduced in size.)



PLATE XII. SECTION OF A TUBERCULOUS HEART (Cow)

PLATE XIII.

Tuberculous gland. A photograph of a cross section of a much enlarged lymph gland. The lighter points indicate centers of calcification. The central area shows infiltrated tissues and the breaking down of the gland tissue. (Natural size.)



PLATE XIII. TUBERCULOUS GLAND

PLATE XIV.

Mediastinal gland. A photograph of a much enlarged tuberculous mediastinal gland cut longitudinally. The central portion shows necrosis and breaking down of the tissue. This gland is normally not more than one and one-half inches long. (Natural size.)

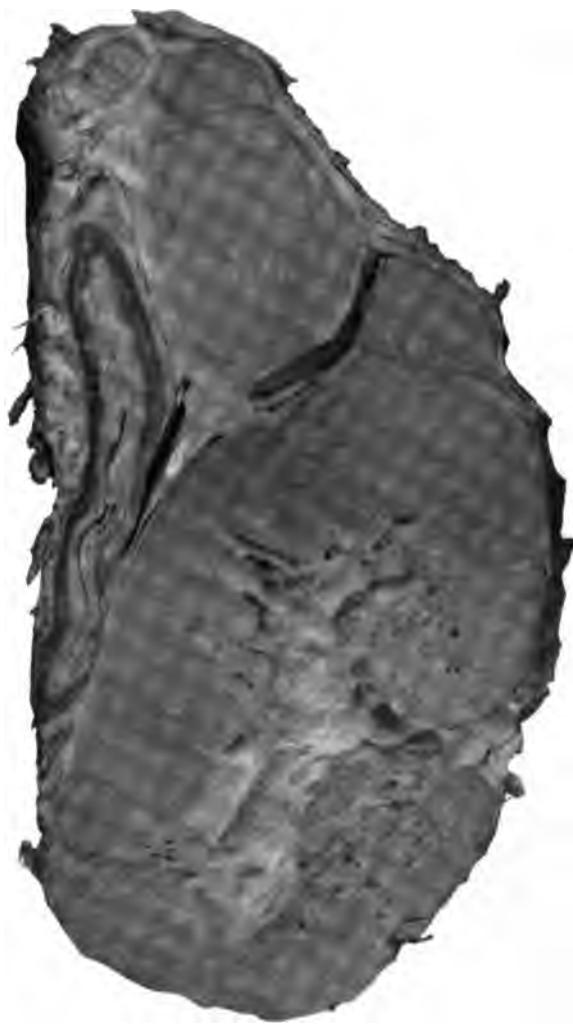


PLATE XIV. TUBERCULOUS GLAND

PLATE XV.

Tuberculous gland. A photograph of (1) a mediastinal gland showing small tubercles (a) many of which are caseous. (2) A chain of lymph glands that are much enlarged. The lower one is split and spread open showing the broken down tissue. (Natural size.)



PLATE XV. TUBERCULOUS GLANDS

PLATE XVI.

Mediastinal gland. A photograph of a longitudinal section of a very large mediastinal tuberculous gland. The outer part shows broken down tissue. The central portion contains a mass of homogeneous exudate occasionally found in the interior of tuberculous glands. (Reduced about one-half.)



PLATE XVI TUBERCULOUS MEDIASTINAL GLAND

PLATE XVII.

Enlarged mesenteric glands. This photograph shows a chain of very much enlarged tuberculous glands (a). They are several times larger than normal. They are hard and contain areas of calcified tissue. (Slightly smaller than natural specimens.)



PLATE XVII. ENLARGED (tuberculous) MESENTERIC GLANDS

PLATE XVIII.

Ulcers in the intestine. This is a photograph of two short strips of the small intestine of a cow showing several small and two large tuberculous ulcers. (Natural size.)

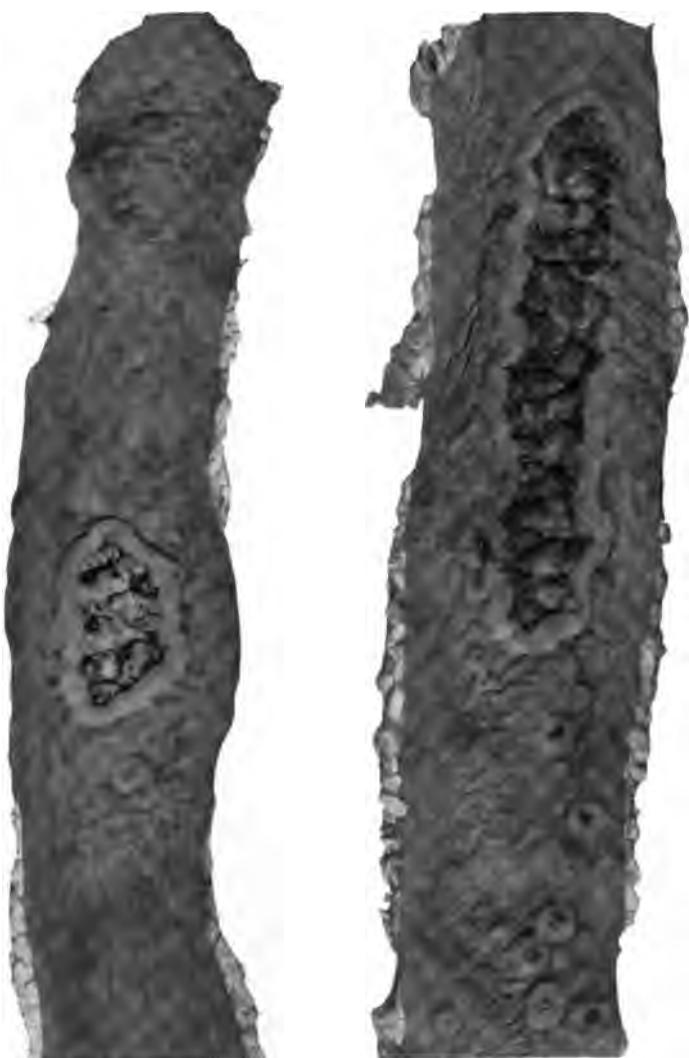


PLATE XVIII. TUBERCULOUS ULCERS INTESTINE

PLATE XIX.

Ulcers and enlarged glands at ileo-caecal valve. A photograph of several small ulcers in the small intestine (a) and a few in the large intestine (b). The lymph glands (c) at the ileo-caecal valve are much enlarged from tuberculous growth. (Natural size.)

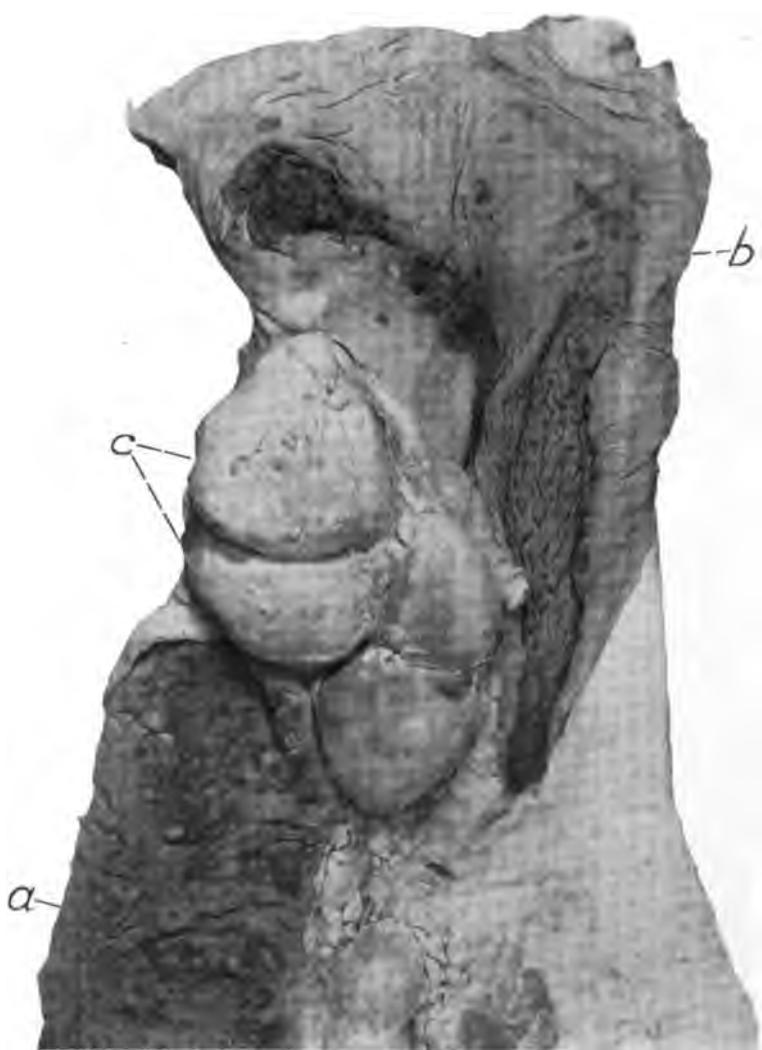


PLATE XIX. TUBERCULOUS ULCERS AND GLANDS AT ILEO-CAECAL VALVE

PLATE XX.

Liver. A photograph of the surface of a small part of the liver of a cow sprinkled with tubercles. The tubercles do not extend deep into the tissue but are confined to the surface. (Natural size.)



PLATE XX. TUBERCLES ON SURFACE OF LIVER

PLATE XXI.

Cross section of liver. A photograph of a cross section through the portal gland of a tuberculous liver of a cow. It shows several tuberculous masses (a) within the liver tissue. In some of these the dead tissue is beginning to calcify. The portal gland (b) is very much enlarged and tuberculous throughout. (Reduced in size.)



PLATE XXI. A SECTION OF A TUBERCULOUS LIVER

PLATE XXII.

Omentum. A photograph of a part of the omentum showing a large number of small more or less flattened tubercles scattered over the surface. (Slightly reduced in size.)



PLATE XXII. A TUBERCULOUS OMENTUM

PLATE XXIII.

Omentum. This is a photograph of a part of an omentum (cow) covered with confluent tubercles. It is a much older and more advanced case than the one shown in Plate XXII. The entire surface is covered. (Natural size.)



PLATE XXIII. A TUBERCULOUS OMENTUM

PLATE XXIV.

Omentum. This photograph shows an omentum (cow) thickly studded with spherical tubercles some sessile and others attached to the omentum by a slender thread of tissue. When sectioned they exhibit dead and partly calcified tissue in the central part. (Natural size.)



PLATE XXIV. A TUBERCULOUS OMENTUM

PLATE XXV.

Spleen. A photograph of the spleen of a cow showing tubercles within the spleen pulp. Several of them contain points of calcification as indicated by the whitish points in the dead tissue. (Considerably reduced in size.)



PLATE. XXV. TUBERCULOUS SPLEEN (Cow)

PLATE XXVI.

Udder. A photograph of a section through a tuberculous udder of a cow. Milk from this udder contained an enormous number of tubercle bacteria. In the living animal the evidence of disease was the slightly swollen and very hard condition of the gland. (Slightly reduced in size.)

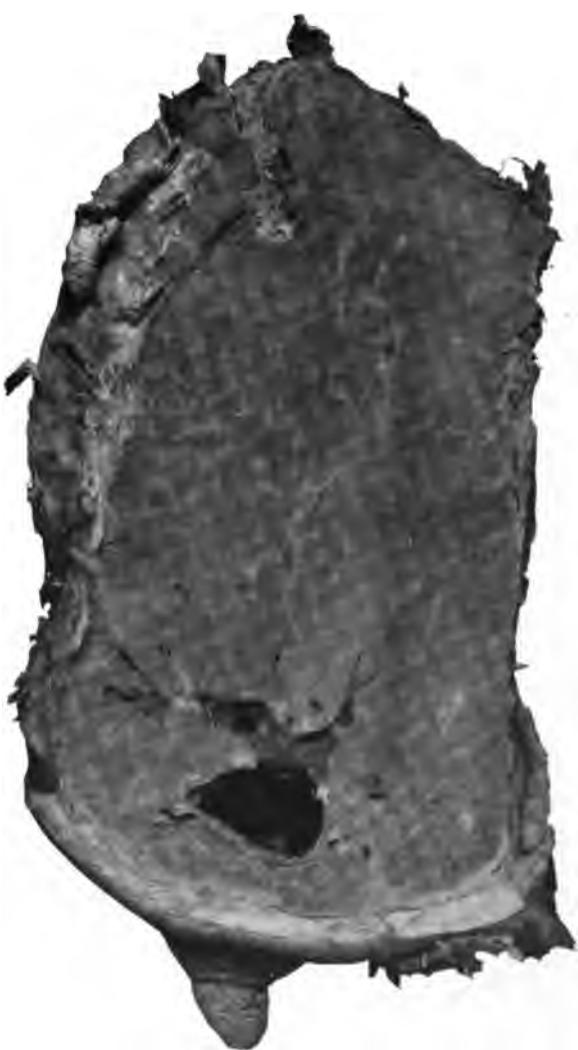


PLATE XXVI. A TUBERCULOUS UDDER

PLATE XXVII.

Skin. A photograph of several sections of the skin each showing a cross section of a tubercle (b) lying in and immediately under the derma. This is a somewhat rare location for tubercles. (Natural size.)



PLATE XXVII. TUBERCULOSIS OF THE SKIN

PLATE XXVIII.

Uterus. A photograph of a tuberculous uterus of a cow. The entire interior surface of the uterus is studded with tubercles. It shows the interior from the os to the fundus. (One-half natural size.)



PLATE XXVIII. TUBERCULOSIS OF THE UTERUS

PLATE XXIX.

Bone. This is a photograph of a longitudinal section through the spinal cord and vertebrae. It shows a large tuberculous mass partially calcified in the vertebra with some pressure upon the spinal cord. This specimen was given me by Dr. W. L. Beebe of St. Paul, Minn. (Natural size.)



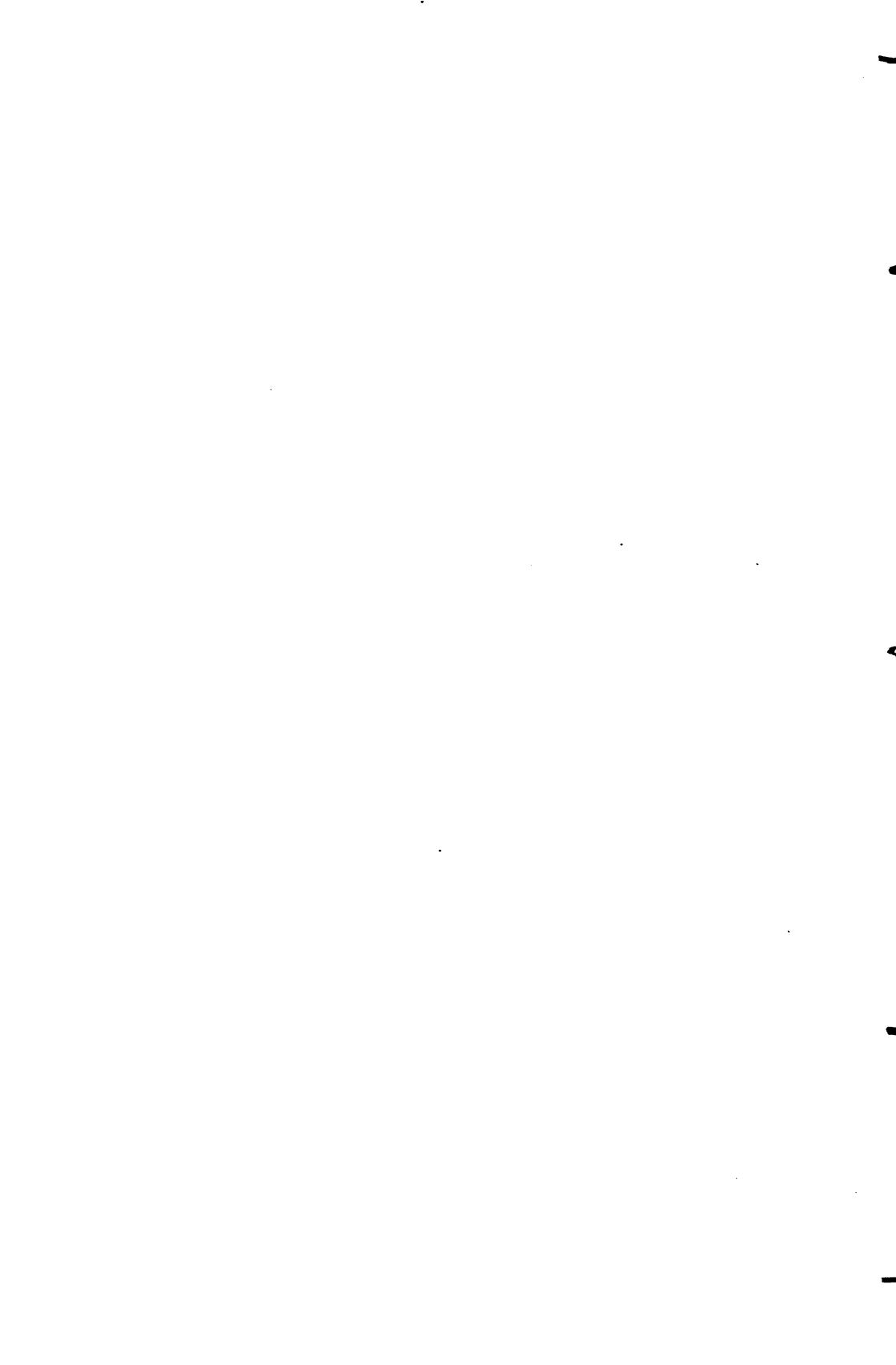
PLATE XXIX. TUBERCULOSIS OF BONE

PLATE XXX.

Spleen. This is a photograph of a pig's spleen containing several tubercles. This pig was infected by drinking the milk from a cow having tuberculosis of the udder. (Natural size.)



PLATE XXX. TUBERCLES IN A PIG'S SPLEEN



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